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UNIVERSITY OF MICHIGAN
OFFICIAL PUBLICATION

COLLEGE OF ENGINEERING

Announcement

1942-1944

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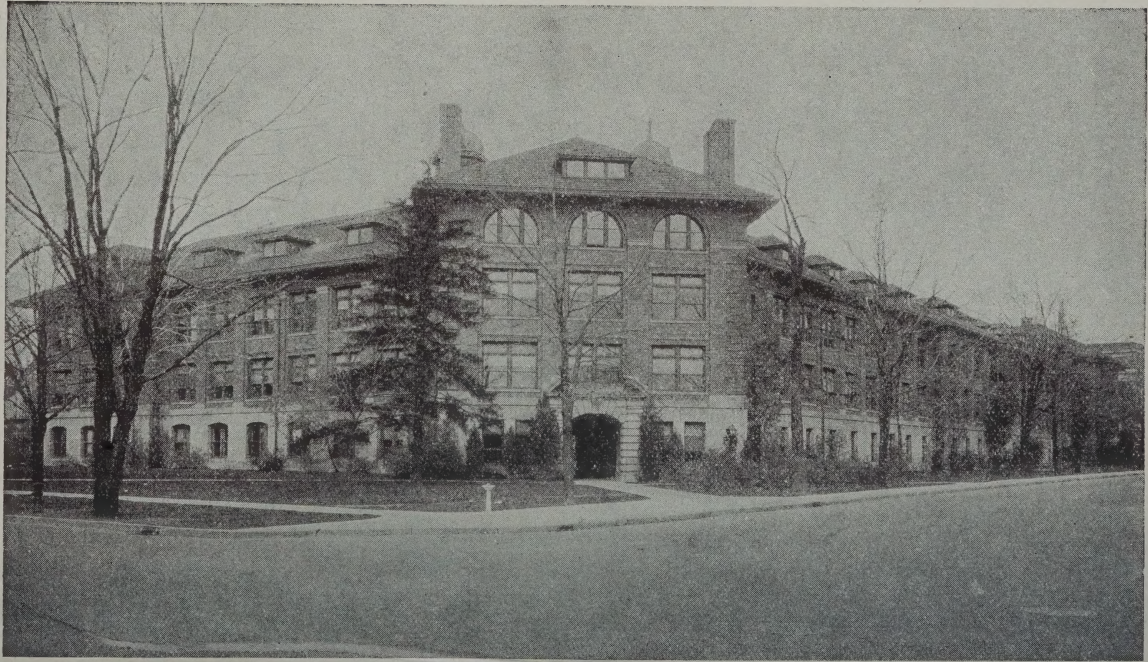

WEST ENGINEERING BUILDING

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ENGINEERING CALENDAR

Academic Year, 1942–43

1942

Summer Term

June 8–13, Monday–Saturday	Engineering registration
June 11–13, Thursday–Saturday	Payment of fees
June 12–13, Friday–Saturday	Classification of all Engineering students
June 15, Monday	Summer term begins
July 4, Saturday	Independence Day, holiday
September 7, Monday	Labor Day, holiday
September 21, Monday	Final examinations for summer term begin
September 26, Saturday	Final examinations for summer term end
September 26, Saturday	Summer term ends

Fall Term

September 28–October 3, Monday–Saturday	Orientation Period and Engineering registration
October 1–3, Thursday–Saturday	Payment of fees
October 2–3, Friday–Saturday	Classification of all Engineering students
October 5, Monday	Fall term begins
November 26, Thursday	Thanksgiving Day, holiday
December 23, Wednesday, evening	Christmas vacation begins

1943

January 4, Monday	Classes resume
January 25, Monday	Final examinations for fall term begin
January 30, Saturday	Final examinations for fall term end
January 30, Saturday	Fall term ends

Spring Term

February 1–6, Monday–Saturday	Engineering registration
February 4–6, Thursday–Saturday	Payment of fees
February 5–6, Friday–Saturday	Classification of all Engineering students
February 8, Monday	Spring term begins
February 22, Monday	Washington's Birthday, holiday
May 20, Thursday	Final examinations for spring term begin
May 26, Wednesday	Final examinations for spring term end
May 29, Saturday	Commencement

Fees. No change in the previously announced schedule of student fees has been occasioned by the adoption of the three-term plan. The fee for each full *term* (including the summer *term*) is the same as the previous *semester* fee of the present schedule, and the fee for the eight-week summer *session* remains unchanged.

Part I

OFFICERS AND FACULTY

ADMINISTRATIVE OFFICERS

Alexander Grant Ruthven, Ph.D., LL.D., Sc.D., *President* — 815 South University Avenue

Shirley Wheeler Smith, A.M., *Vice-President and Secretary in Charge of Business and Finance* — 1706 South University Avenue

Ivan Charles Crawford, C.E., *Dean, College of Engineering* — 1702 Morton Avenue

Alfred Henry Lovell, M.S.E., *Assistant Dean and Secretary, College of Engineering* — 3000 Geddes Avenue

Camilla Blanche Green, *Assistant Secretary, College of Engineering* — 910 Dewey Avenue

Ira Melville Smith, LL.B., LL.D., *Registrar* — 4 Geddes Heights

Albert Easton White, Sc.D., *Director of Engineering Research* — 2110 Dorset Road

FACULTY

Members of the Faculty are listed at the head of the particular field of study in which they serve. A complete list may be obtained from the University's publication *Register of Staff and Graduates.*

EXECUTIVE COMMITTEE

Dean I. C. Crawford, Chairman ex officio
Professor G. G. Brown, term, 1942–1946
Professor S. S. Attwood, term, 1941–1945
Professor R. S. Hawley, term, 1940–1944
Professor R. L. Morrison, term, 1939–1943

STANDING COMMITTEE

Dean I. C. Crawford, Assistant Dean A. H. Lovell, Professors S. S. Attwood, B. F. Bailey, O. W. Boston, E. M. Bragg, C. G. Brandt, G. G. Brown, E. L. Eriksen, L. M. Gram, R. S. Hawley, H. W. Miller, R. L. Morrison, A. M. Kuethe, and A. E. White.

COMMITTEES OF THE COLLEGE OF ENGINEERING

Committee on Classification:

Assistant Professor C. F. Kessler, Professor C. E. Love, Associate Professors D. W. McCready, J. C. Palmer, and M. B. Stout, and Assistant Professor G. L. Alt.

Committee on Scholastic Standing:

Professor C. B. Gordy, Associate Professors L. A. Baier, R. Schneidewind, and I. H. Walton and Assistant Professors A. L. Clark, Jr., and L. N. Holland.

Committee on Discipline:

Associate Professor A. Marin, Assistant Dean A. H. Lovell, Professor R. H. Sherlock, and Assistant Professor E. F. Brater.

Committee on Scholarships:

Professors H. W. Miller, J. C. Brier, Peter Field, F. N. Menefee.

Committee on Substitution and Extension of Time:

Professors R. A. Dodge and J. M. Nickelsen and Associate Professor D. E. Hobart.

Committee on Combined Curriculum:

Professors W. C. Sadler, C. B. Gordy, and C. Upthegrove.

GENERAL INFORMATION

HISTORY

1. The University of Michigan, founded in 1817, is a part of the educational system of the state, and derives from the state the greater part of its revenue.

In the legislative act of 1837, under which the University was organized in its present form, provision was made for instruction in engineering. The first professor of civil engineering was appointed in 1853, and the first degrees were conferred in 1860.

The aim of the College of Engineering is to lay a foundation of sound theory, sufficiently broad and deep to enable its graduates to enter understandingly on a further investigation of the several specialties of the engineering profession, and at the same time to impart such a knowledge of the usual professional practice as shall make the students useful upon graduation in any subordinate position to which they may be called. The technical branches are under the direct charge of those who have had professional experience as well as a full scientific training. The instruction fits the students, as far as possible, for the requirements of active practice. The Department of Engineering Research was established in 1920. The general function and purpose of this department is to co-operate in every proper manner with the industries of the state.

PROGRAMS OF STUDY

2. The College of Engineering has four-year programs of study which are accredited by the Engineers' Council for Professional Development in aeronautical, chemical, civil (including transportation), electrical, mechanical, and metallurgical engineering, naval architecture and marine engineering, and engineering mechanics. In addition four-year curricula not accredited by the Engineers' Council for Professional Development are offered in the specialized fields of astronomy, mathematics, and physics.

The Engineers' Council for Professional Development represents the American Society of Civil Engineers; the American Institute of Mining and Metallurgical Engineers; the American Society of Mechanical Engineers; the American Institute of Electrical Engineers; the American Institute of Chemical Engineers; the Society for the Promotion of Engineering Education; and the National Council of State Boards of Engineering Examiners. It undertakes to formulate criteria for colleges of engineering which will ensure to their graduates a sound educational foundation for practicing the engineering profession.

The work offered by the several departments is usually broader than the name of the department may indicate. For example, under Chemical Engineering will be found metallurgical, industrial, and general chemical engineering; under Civil Engineering will be found geodesy and surveying, structural, hydraulic, transportation, sanitary, and municipal engineering; under Electrical Engineering will be found power, communication, and illumination engineering and electrical design; under Mechanical Engineering will be found steam power, internal combustion, hydromechanical, heating, ventilating and refrigerating, automobile and industrial engineering, and machine design.

The College of Engineering and the Schools of Business Administration, Forestry, and Law, of the University, offer five- or six-year combined courses to meet the needs of those who expect to follow a career in which an engineering background is desirable.

The student in the combined course is registered for the first three years in the College of Engineering, and for the subsequent two or three years in one of the other schools. On the completion of the three-year curriculum in the College of Engineering with a minimum average of 2.5,* the student is recommended for transfer to one of the other schools.

On the satisfactory completion of the first year in one of the other schools, the student will be recommended for the degree of Bachelor of Science in Engineering. The diploma given will bear the legend of the school to which transfer is made. It should be understood that such a degree is not a professional engineering degree and is not so regarded by the Engineers' Council for Professional Development. It is a recognition that the student has completed four years of work composed chiefly of basic engineering training, which has been accepted as preparation for professional degrees and later professional activities in fields other than engineering.

Students in the College of Engineering transferring to one of the other schools without having completed the first three years of the combined course with the required grade will not be recommended by the College of Engineering for its degree.

Attention is called to the fact that the College of Engineering requires a higher average grade for its recommendation for transfer to one of the other schools on the combined course than it does for graduation in the general four-year curricula.

For details see sections 62, 63, and 64.

The Electrical and Mechanical Engineering departments offer a five-year co-operative program with industry, conforming substantially to the following principles: co-operative relations will be established only with such industries as are able and willing to offer a definite program of graded work of educational value. The student will undertake the co-operative work during periods of an entire term or of an entire summer session. Credit for the co-operative work will be given only on completion of the entire prescribed program. For details see sections 56 and 59.

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* For grading system, see section 24.

COMBINED PROGRAMS WITH OTHER INSTITUTIONS

3. The College of Engineering has an agreement with Albion and Kalamazoo colleges and Western Michigan College of Education, under which a student who has been in residence there for three years and who has completed with a good record a prearranged program including substantially the work of the first two years of the College of Engineering, may be admitted to the College of Engineering, and after two additional years may be graduated in engineering.

Under this agreement these colleges accept the first year at the College of Engineering in lieu of their senior year and if the student's record is satisfactory graduate him.

ADMISSION

4. The requirements for admission are the same for all students in engineering.

Applicants must be at least sixteen years of age and must present satisfactory evidence of good moral character. For freshmen, the record of work done in the preparatory school must be presented on a form to be obtained from the Registrar of the University; for students transferring from other colleges, the transcript of record usually includes a satisfactory statement.

Students may be admitted on certificate, by examination, on credits from another college, or by a combination of these. They may also be admitted as special students.

FOREIGN STUDENTS

5. All students whose native language is other than English shall, upon matriculation and registration in the College of Engineering, be required to report at once to Professor J. R. Nelson, Counselor to Foreign Students. Before they may be classified, such students shall satisfy him that they possess a sufficient knowledge of English to carry on work in the College of Engineering.

On recommendation of the Counselor they may be referred to the proper classifier, who will give them such a program of work as he deems best. For his first term, however, every foreign student is considered as on trial. If at the end of the term he passes his work, credit will be given; if, however, in spite of conscientious effort he fails, and his difficulties are, in the judgment of his instructors and of the Counselor, due primarily to his lack of facility in the use of the English language, his record will be disregarded but he will then be remanded to the Department of English for such work in English as he needs, to the limit of 8 hours.

If a student is judged by the Counselor to be unfitted even for such a trial program as that outlined above, he will be required to take for one term such work in English as the Counselor thinks necessary, and may be allowed to visit such classes as may in the judgment of the Counselor be profitable to him.

REQUIREMENTS FOR ADMISSION

6. *a*) Requirements for admission are stated in units, a unit being defined as a course covering an academic year and including in the aggregate not less than the equivalent of 120 sixty-minute hours of classroom work. Two to 3 hours of laboratory, drawing, or shopwork are counted as equivalent to 1 hour of recitation.

Applicants for admission as freshmen must present a minimum of fifteen units which must include four sequences, two major sequences from Groups A and C and two minor sequences from Groups B and D. A major sequence consists of a minimum of three units, a minor sequence of a minimum of two units.

	UNITS
A. English A major sequence of at least 3 units is required	3
B. Foreign-Language Group A minor sequence of 2 units of a single language, Greek, Latin, French, German, or Spanish is required	2
C. Mathematics Group A major sequence of at least 3 units is required. This shall include algebra 1½ units, plane geometry 1 unit, and solid geometry ½ unit	3
(In addition, trigonometry ½ unit is urgently advised, because if not offered for admission it must be elected in the first year of college.)	
D. Science Group A minor sequence of 2 units is required. This shall consist of 1 unit of physics and preferably 1 unit of chemistry, though botany, zoology, or biology may be offered in place of chemistry	2
E. The remaining units required to make up the necessary 15 units are elective from among the subjects listed above and any others which are counted toward graduation by the accredited school. It is recommended that 1 unit of history, or ½ unit of American government and ½ unit of American history, be included in this group. (Such half units are acceptable only if taken in the eleventh or twelfth grade.) .	5
Total	15

Provisional Admission. In general, an applicant for admission either by certificate or by examination who lacks not more than two of the units prescribed may, if he presents fifteen acceptable units, be admitted provisionally. These deficiencies must be made up during the first year of residence, without credit toward graduation, but if elected in college will be used in determining the term-grade average. No student who has an admission deficiency outstanding at the beginning of his second year of residence will be allowed to enter his classes until such deficiency is removed. Only those applicants may be admitted provisionally who, in addition to fulfilling the above conditions, are unqualifiedly recommended by their principals for admission.

NOTES ON THESE REQUIREMENTS

b) **English.**— Four units of English should always be presented whenever it is possible.

c) **Foreign Language.**—No less than two units of any language will be accepted for admission. Foreign languages other than those listed are sometimes accepted in the case of students whose native language is other than English. These cases will be considered individually.

d) **Chemistry and Trigonometry.**—It is urgently advised that one unit of chemistry and one-half unit of trigonometry be included in the fifteen units offered for admission. The student who presents the full requirements without chemistry and trigonometry must take Chemistry 3 and Mathematics 7 or 8 in his first college year, which may necessitate more than the usual time to complete the graduation requirements. Trigonometry is offered in the summer session of the College of Literature, Science, and the Arts to accommodate those students who wish instruction in this subject before entering college.

ADMISSION TO ADVANCED STANDING

7. A student in another college or university who intends to enter the College of Engineering with advanced standing should examine carefully the curriculum of the department in which he intends to specialize, and arrange his work accordingly. The applicant must present to the Assistant Dean a letter of honorable dismissal from an approved college, together with an official transcript of his college work and preparatory studies. The transcript must show a scholastic average of at least a full C pass, 75 per cent. After all entrance requirements are fulfilled the Assistant Dean, with the advice of the various teaching departments concerned, evaluates tentatively, in terms of our own equivalent courses, the advanced credit to be allowed the student. Credit will not be given in general for courses passed with a D, or low-pass grade.

As a rule the student should have completed the required work in English, mathematics, physics, chemistry, physical education, and the nontechnical subjects, and in drawing and engineering mechanics if his institution offers adequate instruction in them. Unless he has had one year of physical education or is granted at least 60 hours of advanced credit, he will be required to complete a year of physical education in the College of Engineering. One year of military science will be accepted in lieu of physical education.

The remaining requirements for students of engineering can usually be completed in two years, if the student takes as electives, while an undergraduate, the mathematics required of engineering students and Courses 1, 2, and 3 in drawing. Students in the College of Literature, Science, and the Arts who desire to transfer to the College of Engineering should consult officials of the College of Literature, Science, and the Arts regarding required and permissible elections.

The student is advised to write to the chairman of the department in which he wishes to specialize for advice and for information not found in this bulletin. The Assistant Dean of the College of Engineering will be glad to give information concerning admission requirements or other matters of a general nature.

Students who receive on admission less than 30 hours of advanced credit are tentatively considered as freshmen; those presumably to be graduated within one year are considered as seniors.

a) A graduate of the University or of an approved college is admitted without examination to advanced standing as a candidate for a degree in engineering. He should present to the Assistant Dean an official certificate of graduation—not diploma—and an official transcript of his studies.

A student who has completed a regular four-year course at an approved college or other institution may be admitted to the College of Engineering as a senior provided that, in general, the course completed has covered substantially the equivalent of the required work in the first three years of the program he desires to follow at the University of Michigan. The courses to be taken during residence at the University will depend upon his previous training and will be determined by the chairman of the department concerned. Upon the satisfactory completion of such courses, covering at least one year's residence, the student will be recommended for the degree of Bachelor of Science in Enginering.

b) A student who has completed at least one year of work with a satisfactory grade average in an approved college may be admitted to advanced standing without examination.

c) A student who has not completed a year's college work in an approved college, but before entering the University has pursued studies beyond those required for admission, may be admitted to advanced standing. Entrance requirements in such cases may be satisfied by complying with conditions set by the University Registrar.

ADMISSION ON COMBINED PROGRAMS

8. Students who have completed the first three years of the combined program arranged by the College of Engineering with Albion, Kalamazoo, and Western Michigan College of Education are admitted as juniors. For the admission of other students from these colleges see the regulations in section 7.

ADJUSTMENT OF ADVANCED CREDITS

9. Advanced credit for studies taken elsewhere is given only for work equivalent to courses offered in the University of Michigan and is adjusted on the basis of semester hours completed without any scholastic grade being assigned to this credit. The student's scholastic average is determined by grades earned while enrolled in this College alone. At the end of the first term after transfer the student's performance is reviewed by the Assistant Dean. If the average grade for the term is 2.0 honor points (C full pass) or better, the tentative advanced credits are validated. If the average grade is below 2.0, the tentative credits are reviewed for readjustment in consultation with the professional department concerned.

Applicants for advanced credit should apply at the time of entrance at Room 255, West Engineering Building. It is desirable that credentials should be submitted as far in advance of registration week as practicable. Students desiring advanced standing in drawing must bring all drawings completed previous to entrance.

ADMISSION AS GRADUATE STUDENTS

10. Higher degrees in engineering are conferred in the Graduate School of the University. See the *Announcement* of the Horace H. Rackham School of Graduate Studies.

ADMISSION AS SPECIAL STUDENTS

11. Students who are pursuing work in college, and are not candidates for a degree, are designated Special Students.

Persons over twenty-one years of age who wish to pursue particular studies in engineering, and who show by examination or by the presentation of satisfactory certificates that they are prepared to do good work in the selected courses, may be admitted as special students on the recommendation of the chairmen of the departments of instruction in which they wish to study. The object of this rule is to enable young men who are beyond the high-school age to secure technical training along special lines when they are properly prepared for the work. Two or more years of successful experience as teacher, draftsman, surveyor, engineer, or operative in engineering work will be given considerable weight in determining the fitness of the candidate. In general, a good working knowledge of English, algebra, and geometry is required in order to succeed in engineering studies. Applicants for admission as special students should send as early as possible to the chairman of the department concerned letters of recommendation, certificates of scholarship, and an exact statement of the courses desired. They should state their age, education, and experience, and should bring drawings to demonstrate their experience and ability.

College graduates are also admitted as special students and may take those courses for which their preparation is sufficient.

Special students pay the same fees as regular students. Their work is assigned and regulated by the chairmen of the departments of instruction in which they register.

A special student may become a candidate for a degree by fulfilling the regular requirements for admission. See section 6.

A student who is a candidate for a degree cannot become a special student without the permission of the Faculty.

FEES AND EXPENSES

12. *The term fees must be paid before classifying for studies, and no student may enter upon his work until after such payment.*

Detailed information regarding registration and payment of fees, also directions for classification, may be obtained from the Secretary of the College.

To cover expenses students are urged to provide themselves with money orders or travelers' checks. For the convenience of students, the Cashier's Office will cash or accept in payment of term or other University fees, money orders or travelers' checks. Personal checks will not be cashed, but will be accepted for the exact amount of fees.

Term Fees.—Every student has to pay a term fee. For Michigan students, the fee in the College of Engineering is $65 for each term, for non-Michigan students, $120 for each term.

These fees cover class instruction, use of libraries, outdoor physical education, admission to all athletic events, and membership in the Michigan Union or Michigan League, as well as medical attention from the University Health Service and dispensary.

Reduced Program Fees.—Six hours or fewer in the Graduate School or the Law School or eight hours or fewer in any other school or college shall be considered a reduced program. Those electing such a program shall pay each term the appropriate fee indicated below.

Before a student may elect a reduced program, permission must be obtained from the dean of the school or college in which enrollment is intended.

Fees

GROUP	DESCRIPTION	MICHIGAN STUDENTS	NONRESIDENTS
1.	Registration for work *in absentia* or election of two hours	$16	$26
2.	Three or four hours	32	42
3.	Five or six hours	45	60
4.	Seven or eight hours	55	70

All students in Groups 1 and 2 may obtain privileges of the Health Service upon an additional payment of $7.50 per term *at the time of registration.* Election of Health Service privileges is entirely optional to these two groups; however, those not electing such privileges shall be required to sign a waiver at the time they register.

All students in Groups 3 and 4 are entitled to Health Service privileges without further payment.

At the time of registration all students in the above five groups may obtain the privileges of Outdoor Physical Education and Michigan Union or Michigan League upon payment of the following appropriate incidental fees: Outdoor Physical Education, $3.75; Michigan Union, $5.00; and Michigan League, $7.50

Determination of Legal Residence.—Residence in Michigan for the purpose of registration shall be determined according to the state constitutional provision governing the residence of electors (see Article III, Sections 1 and 2)—that is, no one shall be deemed a resident of Michigan for the purpose of registration in the University of Michigan unless he is a citizen of the United States who has resided in this state the six months next preceding the date of his proposed enrollment, and no person shall be deemed to have gained or lost a residence in this state while a student in the University. The residence of a minor shall follow that of the parent or the legal guardian. The residence of a wife shall follow that of the husband. Minor students coming to the University from other states or countries shall not be registered as residents of Michigan on the basis of having a resident of Michigan as guardian, except on permission of the Regents in each individual case. Aliens who have taken out their first citizenship papers, and the wives or minor children of such aliens, who have otherwise met these requirements for residence, shall be regarded as eligible for registration as residents of Michigan. Any student who registers improperly under this rule shall, when discovered, be required to pay not only the proper nonresident fees, but shall be assessed, as an addition to the term fee, the sum of $10.00. Discretion to adjust individual cases within the spirit of these rules shall be lodged with the Secretary, with the right of appeal to the Regents.

Late Registration.—Registration (i.e., enrollment, payment of fees, and classification) must be entirely completed before the first day of the term. Students failing to complete their registration before the first day of any term shall pay a late registration fee of $1.00 a day with a maximum of $3.00 for registration three days after the last regular day. In addition a fee of $1.00 will be assessed students who do not complete their classification before the first day of the term.

Laboratory Fees.—No laboratory fees are charged, but those students who take laboratory work in such courses as chemistry, chemical engineering, pharmacy, bacteriology, or hygiene shall pay for the materials actually consumed by them and for unusual breakage. The deposits required in advance range from $5.00 to $20.00, according to the course. The actual expense involved varies with the prudence and economy of the individual student.

Indebtedness to the University.—Students shall pay all accounts due the University not later than the last day of classes of each term. Student loans which fall due during any term which are not paid or renewed are subject to this regulation; however, student loans not yet due are exempt. Any unpaid accounts at the close of business on the last day of classes will be reported to the Cashier of the University and:

a) All academic credits will be withheld, the grades for the term just completed will not be released, and no transcripts of credits will be issued.

b) Students owing such accounts will not be allowed to register in any subsequent term until payment has been made.

Graduation.—The by-laws of the Board of Regents prescribe that no person shall be recommended for a degree until he has paid all money due the University. To receive a degree at Commencement the candidate must be present in person. Others who have satisfied all the requirements for graduation, including the payment of all dues, will receive their degrees at a subsequent meeting of the Board of Regents.

Living Expenses.—For living accommodations and expenses see the *Bulletin of General Information.* The following items are necessary for an engineering student during the first year:

Set of drawing instruments, board, T square, triangles, scales	$40
Slide rule, notebook, paper	15
Textbooks, $25 each term	75

REFUND OF FEES

13. *a*) No student will be entitled to a refund in accordance with scale below except upon (1) presentation to the Cashier of the University of a certificate of withdrawal from the proper official of the school or college from which he or she is withdrawing, and (2) surrender to the Cashier of the University of the student receipt, the outdoor-physical-education coupon or book, together with tickets issued to such student for future athletic events, the Michigan Union or Michigan League annual-membership card, and the student identification card (if one has been issued). In case of loss of the student receipt, $5.00 will be deducted from the refund as a penalty and a further deduction of $1.00 will be made if the student identification card is not surrendered. If the athletic coupon or book or tickets for future athletic events are not surrendered, deductions at face value will be made for such items.

b) No refund will be granted unless applied for within one year after withdrawal.

c) A student who withdraws not more than two weeks after his registration will be entitled to a refund of his entire term fee.

d) A student who withdraws more than two weeks and less than four weeks after the beginning of the term will be entitled to a refund of one-half his term fee.

e) A student who withdraws more than four weeks and not later than eight weeks after the beginning of the term will be entitled to a refund of 40 per cent of his term fee.

f) A student who transfers from one school or college to another will receive a full refund of his fee in the school or college in which he first enrolled and will be required to pay the full term fee in the school or college to which he transfers.

g) A student who transfers from full-time to part-time status will receive a refund in accordance with regulations (*c*), (*d*), and (*e*) above and will be required to pay the entire part-time term fee.

h) A student who transfers from part-time to full-time status will receive a full refund of the part-time term fee and will be required to pay the entire full-time term fee.

i) Refunds for short courses will be made pro rata on the basis of the foregoing rules.

SELF-SUPPORTING STUDENTS AND STUDENT EMPLOYMENT

14. The normal number of hours that students should carry each term is between sixteen and eighteen. Students who support themselves wholly or in part should so inform their classifier and should elect a smaller number of hours. It is very difficult for a student supporting himself to carry a full schedule and retain his health. It is even more difficult under such conditions to carry a full schedule and earn grades sufficiently high to qualify for graduation.

The University does not undertake to furnish manual labor to students, yet a considerable number find opportunities in the city to meet a portion of their expenses. Students desiring employment should apply in person or by letter before they come to Ann Arbor, to the Dean of Students, Room 2, University Hall.

FELLOWSHIPS AND SCHOLARSHIPS

15. There are a number of fellowships and scholarships in the College of Engineering. For details see sections 28 and 29.

There are also appointed annually a few assistants at salaries ranging from $100 to $200. For the most part, these assistants are graduate students and seniors who have shown themselves proficient in certain lines.

ASSEMBLY, MENTOR, AND PLACEMENT SYSTEM

16. *a*) Each engineering class has its separate assembly. The freshman class is brought together once a week, other classes about four times a year. Attendance at freshman assembly is required; unexcused absences subject the absentee to discipline. In freshman assemblies, faculty members and visiting engineers address the students, and the regular business of the class is assured of attention by the class as a whole.

b) Closely connected with these assemblies is the Mentor System. When Orientation Period ends, the Mentor System begins; the faculty adviser continues with his group as mentor for the group. Both socially and in an advisory capacity the mentor is the personal representative of the Dean, so that each student may feel free to call on his mentor at any time with reference to any subject relating to his college life.

The students receive reports on each of their studies through their mentors or faculty advisers. These reports reach the mentor about six weeks after the beginning of the term, and about four weeks before the final examinations; he is therefore able to give the men in his group not merely general advice but definite information as to how they are getting along in their college work.

c) During the senior year each student is requested to fill out a personnel record and file it with his professional department. The chairman of the department, or special officer designated for the purpose, will then assist the student to find satisfactory employment after graduation by furnishing information as to available openings, and arranging contacts and interviews. From what is usually a long experience, the placement officer will advise the student as to the intrinsic merits of the opportunities presented in the special fields.

The interest of the college in placement by no means ceases when a student graduates. Graduates are invited to file a still more comprehensive personnel record. On doing this, they secure all the co-operation the placement officer can give, either in placing a graduate in his first position, or in enabling him to find a better position if he so desires.

HONOR SYSTEM

17. The students of the College of Engineering adopted the following system in 1916: all examinations and written quizzes in the College are held under the Honor System, the object of which is to create that standard of honor which is essential to a successful engineer and a good citizen. Students are expected to uphold the system or declare their objections to it, after having been duly instructed in all its rules. The instructor does not remain in the room during an examination. The students are placed upon their honor to refrain from all forms of cheating and to reprimand a fellow student who acts suspiciously, and in case he does not take heed, to report him to the Honor Committee. Every student must write and sign the following at the end of his examination paper, if he does not ask for an examination under a proctor:

"I have neither received nor given aid during this examination."

The Student Honor Committee consists of nine members appointed by the Engineering Council.

WOMEN STUDENTS

18. All undergraduate women of the University must make arrangements for their rooms, through the office of the Dean of Women, from the list of approved houses. This ruling applies to

the undergraduate women enrolled in the College of Engineering. Individual adjustments can sometimes be made by securing special permission from the office of the Dean of Women.

Matters of scholarship and attendance are handled by Assistant Dean Lovell. Assistant Secretary Camilla B. Green acts as educational mentor for the women in engineering.

RULES GOVERNING ELECTION OF STUDIES

19. *a*) No student shall be permitted to elect fewer than 12 hours, and no student whose grade average for the preceding term is less than 3 shall be permitted to elect more than 18 hours a term (exclusive of military science), except by permission of the classifier.

b) No credit will be allowed to a student for work in any course unless the election of the work is formally entered on his office classification card.

c) After classification, no study can be taken up or dropped without special permission of the classifier. The time for dropping any course without record is limited to eight weeks from the opening of the term. A course may be dropped only with the permission of the classifier after conference with the instructor in the course, and, except under extraordinary circumstances, permission to drop courses after the first eight weeks of the term will be granted only with grade E. Students who have been absent from studies at any time in the term for more than a week, because of illness or other emergency, should consult the Assistant Dean concerning a necessary revision of their programs.

d) All requests must be made out on a printed form furnished by the Secretary of the College.

e) A student is required to drop a part of his work at any time if he appears to be undertaking too much; or to take additional work if he is thought not to be sufficiently employed.

f) Only such students as are regularly enrolled in a class will be allowed to take quizzes, tests, or final examinations in the same.

g) The Faculty reserves the right to withdraw the offer of any elective study not chosen by at least six persons.

h) After matriculation, a student cannot, without special permission of the Faculty, be admitted to examination in any one of the courses given until he has received in the University the regular instruction in such course.

EXCUSES FOR ABSENCES

20. Underclassmen in the College of Engineering must take the initiative in securing from the Assistant Dean excuses for absences from classes, which excuses must be applied for within five days after the return to classes. Upperclassmen* should explain irregularities of attendance to their instructors.

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* For the definition of upperclassmen, see section 21.

Unexcused absences from Assembly during the freshman year are considered by the Discipline Committee as acts of insubordination. After two absences unexcused by the Head Freshman Mentor, the student may be placed on probation by the Discipline Committee. For more than two unexcused absences, the Discipline Committee may send the student home for insubordination.

CLASS STANDING

21. The following classification of a student in terms of credit hours applicable to his program has been approved by the Faculty: sophomores should have from 30 to 33 hours, juniors 67 to 70 hours, and seniors 100 to 104 hours, or a reasonable chance to graduate within a year. The Assistant Dean will make decisions in unusual cases. The Faculty recognizes as upperclassmen: (*a*) those students in good standing, i.e., not on probation, who have obtained at least 67 hours of credit, with an average grade of at least C for all work taken at the University of Michigan; (*b*) all new students who have completed a four-year program at approved colleges and other like institutions; and (*c*) other new students with good previous records who in the opinion of the department heads may qualify for graduation within one year.

An upperclassman's privileges will be withdrawn should his average grade for all work at the University fall below C or should he be put on probation, and will be restored when his delinquency is removed.

Upperclassmen are not required to obtain excuses for irregularities of attendance from the Assistant Dean, but should explain them to their instructors.

ADMISSION DEFICIENCIES

22. An applicant who fails, or is deficient, in some part of the admission requirements may, at the discretion of the Assistant Dean, be admitted, provided he passes in fifteen units; but the removal of entrance deficiencies shall take precedence of all other work; any deficiency must be removed at one of the next two regular examinations for admission, but the classifier is empowered and instructed to see that students entering this college with deficiency remove the same as far as possible during the first term of residence.

No student who has any admission deficiency, with the exception of physics, outstanding at the beginning of the second year of residence will be allowed to enter his classes until such deficiency is removed, unless for valid reason an extension of time is granted for its removal.

EXAMINATIONS

23. Examinations in college work are held at the end of each term, but classes are liable to be examined at any time, without notice, or with one week's notice, on any portion of their work. The

regular examination in any course at the end of each term is an essential part of the work of the course.

MARKING SYSTEM

24. At the end of each term the quality of the work of every student in each course which he elects and completes is reported by the instructor as A (excellent), B (good), C (satisfactory), D (passed), or E (not passed).

When a student is prevented by illness or by any other cause beyond his control from taking an examination or from completing any other part of a course, or if credit in a course is temporarily withheld for any reason, the mark I with a qualifying grade may be given to indicate that the course has not been completed. An incomplete course is thus reported IA, IB, IC, ID, or IE. The grade indicates the quality of work done in the part of the course which has been completed.

Any student absent from an examination is required to report to his instructor as soon thereafter as possible. If a student presents a valid excuse for his absence, he may take the examination at such time as may be arranged by the instructor. In order that credit for a course may be given it must be completed before the end of the eighth week of the term of residence next succeeding that in which it was elected.

The final grade in a course which has been completed during the term of residence following that in which it was elected will be based upon all of the work done in the course. It will not necessarily be the grade reported for the partially completed course.

At the time of completing a course students must obtain from the Secretary a blank form for presentation to the instructor. The blank when filled out is to be sent at once by campus mail, or delivered by the instructor, directly to the Secretary's office.

RULES GOVERNING GRADES AND SCHOLARSHIP

25. *a*) The average term grade and the general average grade is computed for each student at the end of each term and becomes part of his permanent record.

b) The average grade is determined on the basis of A equals 4 points, B equals 3 points, C equals 2 points, D equals 1 point, and E equals 0.

c) The average grade is computed by multiplying the number corresponding to the grade in each course by the hours of credit for the course and dividing the sum of these products by the total number of hours represented by all the courses elected. A supplementary grade removing an incomplete shall be used in computing averages when that grade is different from the original term grade qualifying the report of incomplete.

d) No student who has earned a general average grade below 2.0 on the courses elected in this College may be graduated.

e) A student whose average grade for a term is from 1.7 to less than 2.0 shall be automatically placed on the warned list.

f) A student on the warned list whose average for the following term is 2.0 or better shall be restored to good standing, provided his general average grade is 2.0 or better; if not he shall be continued on the warned list.

g) A student on the warned list whose average for the following term is from 1.7 to less than 2.0 shall be automatically placed on probation.

h) When the average term grade of a student falls below 1.7 he is automatically placed on probation.

i) A student on probation who obtains an average term grade of 2.0 or more is automatically removed from probation, provided his general average is 2.0 or better; if not he shall be placed on the warned list.

j) A student on probation or under warning shall not be removed from the probation or warned list unless he elects and carries at least 12 hours of work in a term.

k) A student will be required to withdraw from this College for any one of the following reasons:

1. If his average term grade falls below 1.1.
2. If he is on probation and fails to obtain an average grade of 2.0, or C, during a term.
3. If he is on the warned list and obtains a term average below 1.7.
4. If he has been on probation during any two terms and subsequently fails to obtain an average term grade of 1.7.

l) In cases of extenuating circumstances, at the discretion of the Committee on Scholastic Standing, students on the warned list or probation may be removed from these lists, and students who have been required to withdraw may be reinstated on probation.

m) A student who is placed on probation or under warning at the end of a term must repeat as soon as possible all courses in which he received a grade of D in that term. In exceptional cases this requirement may be waived by the student's department of specialization (for freshmen, the Assistant Dean).

n) Any student may at his own option repeat a course in which he has a D grade provided he does so during the next two terms he is in residence.

o) Except as provided above, a student may not repeat a course which he has already passed. In exceptional cases this rule may be abrogated by the student's department of specialization (for freshmen, the Assistant Dean) upon recommendation of the department of instruction concerned.

p) All grades received in legally repeated courses shall be included in computing the student's average grade.

WITHDRAWAL FROM THE COLLEGE

26. A student should not withdraw from class even temporarily without obtaining permission from the Assistant Dean.

Leave of absence will be granted to those who expect to return before the end of the year.

Honorable dismissal will be granted to those who wish to transfer to another College of the University and to those going elsewhere, provided in either case they are in good standing. (The written approval of parent or guardian is generally required.)

Engineering students must obtain this permission or dismissal from the Assistant Dean.

SOCIETIES

27. The Engineering Council.—The Engineering Council of the University of Michigan, formed under a constitution in 1927, is an organization of students representing all departments of the College of Engineering. Its members are the presiding officers of the student branches of the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the American Society of Mechanical Engineers, and the American Society of Civil Engineers; of Tau Beta Pi, Sigma Rho Tau, Triangles, and Vulcans; of the Quarterdeck, Aero, and Transportation clubs; the presidents of the freshman, sophomore, junior, and senior classes, together with one special representative from the sophomore class to serve for three years, and two representatives from the junior class to serve for two years; and the editor of the *Michigan Technic.* The Council aims to co-ordinate the activities of the various technical societies and clubs, to assure continuity in policy for the classes, and to develop co-operation between the student body and the faculty.

The Michigan Technic.—The students publish monthly for eight months of the school year a magazine called the *Michigan Technic,* which contains articles contributed by alumni, faculty, and students on technical topics and other matters of interest in the College.

Student Branch, American Society of Civil Engineers.—This chapter was founded in 1923. At the present time its membership consists of civil engineering students from the sophomore, junior, and senior classes who are in good standing in the University. New members are elected each term upon written application.

Mechanical Engineering Section.—This section of the general society is also a *student branch of the American Society of Mechanical Engineers.* Meetings of the section are held about once a month. Some of the meetings are of a purely social nature while others are addressed by members of the faculty or by outside engineers and business men on subjects of general interest to the profession.

Electrical Engineering Section.—This section is a *student branch of the American Institute of Electrical Engineers.* In joining it, the student makes a connection which usually extends throughout his whole professional life after graduation, and which helps him materially by furnishing opportunities for advancement. The meetings, which are held twice each month, are managed entirely by the students, who procure speakers from among themselves or from professionals in the field, and who derive valuable experience in self-expression, as well as technical knowledge, from the discussions which they must make for themselves. Each member of the branch receives *Electrical Engineering,* which is issued once each month.

Chemical Engineering Section.—This section is a *student branch of the American Institute of Chemical Engineers.* The student branch holds meetings where subjects of professional interest are discussed. It has been assigned a clubroom in the East Engineering Building.

The Transportation Club is an organization formed by students with a mutual interest in the general subject of transportation. It forms a common meeting ground for students of railroads, highway engineering and transport, aeronautics, marine engineering, business administration, and economics. Because of its universal nature, it has developed a general appeal to the student body, and the monthly meetings are addressed by prominent engineers.

Tau Beta Pi, the national engineering honor society, has a chapter in the College of Engineering. For membership in this society good scholarship is essential.

The National Society of Sigma Xi has a chapter in the University. The aim of the society is to encourage research. High scholarship and the promise of ability in research are required of its candidates.

The Stump Speakers' Society of Sigma Rho Tau.—This is a branch of the intercollegiate engineering speakers' society founded at the University of Michigan to develop ability in public discussion and debate. The major object of the organization is to ensure a closer bond of understanding between the applied scientist and the general public through the development of speech activities among colleges of architecture, engineering, and technology. The society has a package library and clipping service in its library reference room in the West Engineering Building. It debates national engineering problems with local societies and adjacent branches.

Phi Eta Sigma, a national honorary society for freshman men, elects members each year on the basis of high scholarship.

Phi Kappa Phi, a national scholastic honor society, elects its members each year from the senior classes of all schools and colleges on the basis of scholarship, personality, and service to the University.

FELLOWSHIPS

28. About thirty fellowships and scholarships are open to students in the Graduate School. Appointment is for the term of one year, but appointees are eligible for reappointment. An appointee is not required to render any service to the University aside from that involved directly in the responsibilities of the fellowship or scholarship assigned. It is expected that appointees devote all their time to their graduate work.

A distinction is drawn between fellowships and scholarships, the former, besides carrying the larger stipend, being assigned to the students of more experience and more clearly proved ability and independence in graduate study and research.

A list of these, with the conditions governing them, are given in a special bulletin on *Scholarships, Fellowships, Prizes, and Loan Funds,* which will be sent by the Registrar of the University upon request.

SCHOLARSHIPS, PRIZES, AND STUDENT AIDS

29. A limited number of University scholarships are given in the Graduate School which provide a stipend equal to the amount of the term fees, but not miscellaneous fees, and are open to residents of the state of Michigan who are graduates of the University of Michigan.

American Bureau of Shipping Prize.—A prize of $100 is offered each year by the American Bureau of Shipping to the student in Naval Architecture and Marine Engineering who obtains in the regularly prescribed courses the highest average for the last two years of the curriculum.

Joseph Boyer Fund.—Established in 1938 by gift from Mrs. Henry E. Candler, Grosse Pointe, Michigan, as a memorial to her father. The income is to be used for the benefit of a member of the junior or senior class in the College of Engineering. The recipient of the award must be partially or entirely supporting himself in college, and must have shown himself to be a loyal American citizen.

University Scholarships

Cornelius Donovan Scholarships.—These scholarships were established in 1922 by a bequest of Cornelius Donovan, C.E., '72, Eng.D.(hon.), '12, for award to meritorious senior students in engineering who are working their way through college. These scholarships are awarded in amounts of $200 each. To be eligible, students must be American citizens, partially or entirely self-supporting, and must have completed a minimum of forty-five units of work at the University of Michigan with a minimum general average of 2.5.

Applications must be filed in the office of the Assistant Dean of Engineering before April 1. The awards are published in May and are paid in the amounts of half of the award when the recipients have enrolled for the fall term and half when they have enrolled for the spring term of the following year.

Robert Campbell Gemmell Memorial Scholarships.—This scholarship fund in memory of her brother, Robert Campbell Gemmell, B.S.(C.E.), '84, C.E., '95, M.Eng.(hon.), '13, was founded in 1926 by Mrs. Lillian Gemmell Boal (Mrs. S. H. Boal) of Oakland, California, by a gift to the University of $10,000. It is available for freshman or sophomore students in the College of Engineering who are of general worthiness and deserving character. These scholarships are awarded in amounts of about $100 each. To be eligible, students must be American citizens, partially or entirely self-supporting, and must have completed a minimum of fifteen units of work at the University of Michigan with a minimum general average of 3.0. Applications must be filed in the office of the Assistant Dean of Engineering before April 1. The awards are published in May and are paid in full in September after the recipients have enrolled for the first term of their sophomore year.

Harriet Eveleen Hunt Scholarships.—This trust fund was established in 1937 by Mr. Ormond E. Hunt, B.S., '07, M.E.(hon.), '32, as a memorial to his mother. The income from the fund is distributed in annual awards. To be eligible, students must be American citizens, partially or entirely self-supporting, and must have completed at least fifteen semester hours of work at the University of Michigan with a minimum average of 2.5. Application must be filed in the office of the Assistant Dean of Engineering before April 1. The awards will be paid the same as the Donovan Scholarship.

Simon Mandlebaum Scholarships.—These scholarships were established in 1929 by the late Mary S. Mandlebaum (Mary S. Mandelle) of Detroit, Michigan, in memory of her father, Simon Mandlebaum. These scholarships are awarded in amounts of about $400 each. To be eligible students must be American citizens, partially or entirely self-supporting, and must have completed a minimum of forty-five hours of work applicable for the degree. They must have been in residence at the University of Michigan for at least one year. Applications must be filed in the office of the Assistant Dean of Engineering before April 1. The awards are published in May, and are paid in equal amounts when the recipients have enrolled for the first and second terms respectively of the following school year.

Frank Sheehan Scholarship in Aeronautics.—This scholarship was founded in 1929 by Miss Mildred Sheehan as a memorial to her brother, Frank P. Sheehan, a student in the University from 1917 to 1919 and in 1924–25. The income on this gift of $20,000 is used as a scholarship or scholarships for students who intend to follow a career in aeronautics or aeronautical engineering. It is available to students who have completed at least two years' work in the College of Engineering with a grade distinctly above the average. Usually two scholarships are available each year.

Minnie Hubbard Smith Revolving Fund.—This fund is dispensed as gifts to juniors and seniors in civil engineering. Applications should be made to the Chairman of the Department of Civil Engineering.

LOAN FUNDS

30. The following loan funds have been established especially for the use of engineering students who are in need of aid to complete their studies: Class of 1915 Engineering Loan Fund and Benjamin Sayre Tuthill Loan Fund, George H. Benzenberg Loan Fund and William J. Olcott Scholarship Loan Fund (not available for freshmen); Class of 1914 Engineering Loan Fund (for seniors, no interest before note matures); Class of 1917 Engineering Loan Fund and the John Frank Dodge Loan Fund (for juniors and seniors); Marian Sarah Parker Memorial Fund (for women); and J. B. and Mary H. Davis Trust Fund (Geodesy and Surveying). These special loan funds, together with a number of all-University funds which are open to students in engineering, are described in the bulletin, *Scholarships, Fellowships, Prizes, and Loan Funds,* which is available on request. Applications should be made to the Dean of Students, Room 2, University Hall.

DEGREES CONFERRED IN THE COLLEGE OF ENGINEERING

31. The University of Michigan confers on all graduates of the College of Engineering the degree of Bachelor of Science in Engineering, the diploma designating the branch of engineering that the student has pursued. See section 2 for programs of study.

DEGREES CONFERRED IN THE HORACE H. RACKHAM SCHOOL OF GRADUATE STUDIES

32. Graduate courses are offered in the Horace H. Rackham School of Graduate Studies leading to the degrees of Master of Science in Engineering, Master of Science in Public Health Engineering, Doctor of Philosophy, Doctor of Science, Civil Engineer, Mechanical Engineer, Electrical Engineer, Chemical Engineer, Metallurgical Engineer, Naval Architect, Marine Engineer, Aeronautical Engineer, and Public Health Engineer.

Any student who has received a bachelor's degree from the College of Engineering of this University or from some other university or technical school of recognized standing may enroll in the Graduate School for the degree of Master of Science in Engineering and for other higher degrees. See the *Announcement* of the Horace

H. Rackham School of Graduate Studies, which may be had on application.

Students enrolled in the Graduate School must have a subject of specialization but studies may not be selected exclusively in the single department concerned with the subject. Cognate subjects should be selected in other departments. While it is expected that at least half of the work will be in a single department and also that the work will have unity, narrow specialization is discouraged. After a student has selected his department of specialization he should confer with the professors under whom he expects to study and with them arrange the details of his course.

REQUIREMENTS FOR GRADUATION

33. To secure a degree in the College of Engineering, a student must meet the following requirements:

a) He must complete the required courses of his department.

b) He must complete a sufficient number of electives approved by the head of his department to make a total of 140 credit hours with an average grade of 2 or above. See section 25.

The University year is composed of three equal terms. Each term is the equivalent of one full semester. The credits are granted in semester hours.

A credit hour represents as a rule 1 hour of recitation or lecture a week for one term, preparation for which should require 2 hours of study; or in the case of laboratory work, the credit hours are one-half to one-third of the actual hours spent in session, the time required depending on the necessary home work.

c) He must spend one year in residence and complete at the University of Michigan a minimum of 30 credit hours of the 140 hours required.

d) He must obtain a total of 148 credit hours to receive degrees in two departments, and he must complete the requirements for both degrees.

To be recommended for a degree, a student must file his application in 263 West Engineering, early in the term or summer session during which he expects to complete his work for the degree. If the work is not completed in the period for which the application is filed, the student must file an application in the term or summer session in which he expects to complete his degree requirements.

All students who complete the requirements for graduation and are entitled to receive degrees in May are expected to be present at the Commencement exercises.

NONTECHNICAL ELECTIVES

34. All regular students in the College of Engineering are required to complete not fewer than 6 hours of nontechnical electives selected as follows:

No course offered by an engineering professional department or by the Department of Metal Processing or of Chemistry shall be considered as nontechnical, except that plane trigonometry and Chemistry 3 when taken for University credit will be accepted in place of nontechnical electives.

Not more than 4 semester hours of military or naval science shall be considered as nontechnical.

If as many as 6 hours in any subject except English are required for graduation, any hours in excess of 6 in such subject shall not be considered as nontechnical.

Up to 6 hours in any subject not required in a particular program for graduation may be considered as nontechnical electives, except as limited in the preceding rules. Where less than 6 hours of any permissible subject is required for graduation, the difference between this requirement and 6 hours may be considered as nontechnical.

Students in aeronautical engineering are advised to elect German; and students in astronomy, mathematics, and physics are advised to elect both French and German. Students who expect to do graduate work in chemical engineering are urged to acquire a reading knowledge of German.

EAST ENGINEERING BUILDING

Part II

NONPROFESSIONAL DEPARTMENTS

STUDIES OF THE FIRST YEAR

35. There is a common first year for all students entering without deficiencies or advanced credits. After the first year, each student indicates the branch of engineering he expects to follow and is then enrolled as a student in that branch.

In the second year there is some variation among the curricula for the different branches of engineering, though not so great as to make transfers difficult; but in the third and fourth years there are marked differences, and a student transferring from one department to another does so with difficulty and with some loss of time.

The schedule of studies for first-year students is as follows:

FIRST TERM		SECOND TERM	
COURSES	HOURS	COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4	Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 1	3	*English 3	2
*English 2	1	*English (Group II)	2
Drawing 1	3	Drawing 2	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5	†Ch.-Met. Eng. 1 and Metal Proc. 2 or Chem. 5E	5
Assembly	0	Assembly	0
Physical Ed. or Mil. or Nav. Science	0 or 1	Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17		16 or 17

Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (1 hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

Schedules of studies for later years will be found under the work of the various degree-conferring departments.

The above schedule assumes that the student has presented for admission the full requirement in algebra and geometry, and also trigonometry and chemistry as described in section 6*a*. Should the student have entered without trigonometry or chemistry, or both, the schedule will be modified by substituting Mathematics 7 or 8 for Mathematics 14 and/or Chemistry 3, first term, followed by Chemistry 4, second term, in place of Chemistry 5E. The student entering without solid geometry will take Mathematics 6 without credit.

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

In case the admission requirements have been fully met on entrance, the trigonometry described in section 6*a* and Chemistry 3 taken in college will give credit toward graduation as nontechnical subjects. See section 34.

The classifier in consultation with the student will arrange a schedule intended to adjust the irregularities as quickly as possible. Students are required to remove all deficiencies, with the exception of physics, during this first year, unless granted an extension of time for their removal. See section 22.

The University year is composed of three equal terms. Each term is the equivalent of one full semester. The credits are granted in semester hours.

NONPROFESSIONAL COURSES

36. In the following sections are listed courses given entirely, or primarily, for students in engineering, and in addition those courses which frequently are elected by them. For other courses see the *Announcements* of the College of Literature, Science, and the Arts, the School of Business Administration, and others.

A course in another college that is listed in any engineering curriculum may be elected by our students without special formality; but the approval of the deans, readily obtained, may be required when the course is not intended for engineers. Lack of proper preparation for the course is sufficient reason for approval to be refused.

Besides the departments listed below, in which our students make frequent elections, there are many others which freely and hospitably receive our students. The College of Engineering in the same way receives students from other colleges of the University.

37. BACTERIOLOGY AND WATER ANALYSIS

Professor Soule, Assistant Professor Emerson, and Dr. Mickelson.

105. **Water Analysis.** Open to students of sanitary engineering and to others who are qualified. Tu and Th afternoons. 1552 East Medical Building. Two hours credit. First half of the fall term.

105a. **Special Problems in Water Analysis.** Hours and credit to be arranged. Each term.

110. **General Bacteriology.** Lectures and recitations are given during the spring term. Qualified students from all schools and colleges may elect this course as it is the only lecture course offered by the department. *Prerequisite: Chemistry 53.* Four hours credit. Spring term.

111A. Practical Bacteriology. A laboratory course open to students other than those of the Medical School. *Prerequisite: Chemistry 53.* Three hours credit. Second half of the fall term.

[**111E. Practical Bacteriology.** Open only to students of sanitary engineering. Three afternoons each week. 2552 East Medical Building. Two hours credit. Second half of the fall term, beginning in November. Omitted in 1942–43.]

205. Microbiology. A combined lecture and laboratory course dealing with the chemical activities of microorganisms. Following a general consideration of these agents, especial attention will be devoted to industrial processes in which bacteria, yeasts, and molds play an important role. *Prerequisite: Chemistry 53.* Three hours credit. Spring term.

38. BUSINESS ADMINISTRATION

Professors Griffin, Paton, Rodkey, Jamison, Blackett, Elliott, Gault, Riegel, Waterman, Wolaver, and others.

The courses listed below are those which are deemed of special interest to engineering students. In the election of such courses attention is called to the administrative rules of the School of Business Administration which affect elections as follows:

1. No student shall elect courses in the School of Business Administration who does not have at least third-year standing.
2. Juniors may elect courses numbered 1 to 199 inclusive, provided they have a scholastic rating of 2.5.
3. Courses numbered above 200 may be elected only by properly qualified graduate students and are *not* open to juniors and seniors.

For a description of courses in Business Administration, see the *Announcement* of that School.

39. CHEMISTRY

Professors Schoepfle, Willard, Bartell, Fajans, and Bachmann; Associate Professors Ferguson, Anderson, Halford, Brockway, and McAlpine; Assistant Professors Carney, Meloche, Hodges, Weatherill, Case, Soule, and Gillette; Dr. Horning and Dr. Keller.

The aims of the fundamental course in general chemistry, required of all engineering students, are primarily the development of a scientific attitude and the acquisition of such chemical facts as form a part of the store of knowledge of any well-informed person. Further courses in analytical, organic, and physical chemistry are required of students in chemical engineering.

The Chemistry Building provides excellent facilities for the work of all the Schools and Colleges of the University. Lecture and classrooms, laboratories for class instruction and individual research, a fully equipped stock room, and the chemical library are all located in the one building. The library contains about 11,000 volumes and is especially rich in complete sets of journals; 114 journals are currently received.

COURSES IN CHEMISTRY

3, 4. General and Inorganic Chemistry.* The chemistry of the nonmetallic elements (Chem. 3) and of the metallic elements (Chem. 4), with special emphasis upon the interpretation of chemical phenomena from the viewpoint of modern theory. Two lectures, two recitations, and two two-hour laboratory periods. *Chem. 3 is a prerequisite for Chem. 4.* Four hours credit each. Each term.

5E. General and Inorganic Chemistry. The fundamental principles of chemistry and a study of the more important elements and compounds, omitting the common nonmetallic elements. Two lectures, two recitations, and two three-hour laboratory periods. *Open to students who have presented a unit of chemistry for entrance and have passed the placement examination given during the Orientation Period.* All other students should elect Chem. 3, credit for which will be counted as a nontechnical elective. Five hours credit. Each term.

21E. General and Analytical Chemistry. Includes systematic qualitative analysis for the more important metals and acids, the principles of chemical equilibrium, and the simpler methods of volumetric analysis. Three lectures or recitations and two three-hour laboratory periods. *Prerequisite: Chem. 5E or 4, or equivalent.* Four hours credit. Each term.

41. Quantitative Analysis. Includes the study of gravimetric, volumetric, and electrolytic methods, and the analysis of simple mixtures. The solution of stoichiometric problems is emphasized. Two recitations and three four-hour laboratory periods. *Prerequisite: Chem. 21E.* Four hours credit required. May be taken for five hours. Each term.

53. Organic Chemistry. Intended for students who desire a more elementary course than Chem. 67E and 169E. Four lectures or recitations. *Prerequisites: Chem. 5E or 4, or equivalent.* Four hours credit. Each term.

67E. Organic Chemistry. The properties and classification of carbon compounds. Lectures and recitations. *Prerequisite: Chem. 21E.* Three hours credit. Each term.

85E. Elementary Theoretical and Physical Chemistry. The fundamentals of physical chemistry with particular emphasis on the solution of problems. The subjects treated include the gaseous, liquid, and solid states, solutions and thermochemistry. Three lectures or recitations. *Prerequisites: Chem. 21E or equivalent, Phys. 46, and a knowledge of calculus.* Three hours credit. Each term.

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* Engineering students entering without chemistry will elect Chem. 3 and 4. Those presenting an approved unit of chemistry for entrance will take Chem. 5E unless advised to elect Chem. 3 and 4 as a result of the Orientation Period examination. All students satisfactorily completing the work will be allowed credit for Chem. 3 as a nontechnical elective.

87E. Elementary Theoretical and Physical Chemistry. A continuation of Chem. 85E. Special emphasis will be placed on the subjects of chemical equilibrium and chemical kinetics. Three lectures or recitations. *Prerequisite: Chem. 85E or its equivalent.* Three hours credit. Each term.

141. Advanced Quantitative Analysis. The analysis of some technical products, including coal, iron, and other ores, a silicate rock, and ferrous and nonferrous alloys. Lectures and quiz, twice a week; laboratory, two or three periods a week. *Prerequisites: Chem. 41 and Phys. 36.* Four or five hours credit. Fall and spring terms.

169E. Organic Chemistry. A continuation of Chem. 67E. Lectures, recitation, and laboratory. *Prerequisite: Chem. 67E.* Five hours credit. Each term.

171. Electrochemistry. An elementary treatment of the fundamentals of the subject. Two lectures. *Prerequisite: Chem. 87E.* Two hours credit. Fall term.

185, 186. Physicochemical Measurements. Methods for the determination of molecular weight, viscosity, surface tension, reaction rate, solubility, etc., optical measurements with polarimeter, refractometer, spectrometer. Laboratory work. *Must be preceded or accompanied by Chem. 41 and 85E.* Two to four hours credit. Each term.

188. Physical Chemistry. A course in the fundamentals of physical chemistry particularly for students enrolled in the Curriculum in Physics, others by special permission. Four lectures. *Prerequisites: Chem. 4 or 5E, 21E, and calculus.* Four hours credit. Spring term.

234. Physicochemical Methods in Quantitative Analysis. Lectures and laboratory work. *Prerequisites: Chem. 87E and 141.* Two hours credit. Spring term.

253. Advanced Organic Chemistry and Ultimate Analysis. Laboratory work and reading. *Prerequisite: Chem. 169E.* Two to five hours credit. Each term.

255. Advanced Organic Chemistry. The commercial preparation of intermediates and dyes, and certain topics in the theory of organic chemistry. Two lectures and reading. *Prerequisite: Chem. 169E.* Two hours credit. Fall term.

256. Advanced Organic Chemistry. The industrial application of some catalytic processes, and the synthesis of plastics, rubber, fibers, etc. Two lectures and reading. *Prerequisite: Chem. 169E.* Two hours credit. Spring term.

285. Physicochemical Measurements. A continuation of Chem. 185, 186. The work includes electrical measurements such as conductivity, transport numbers, and electromotive force, work with the hydrogen electrode, experiments with colloids, and the determination of some of the more important physicochemical constants. One to four hours credit. Each term.

291. Colloid Chemistry. The fundamental principles. Two lectures. *Open only to those obtaining permission of the instructor.* Two hours credit. Fall term.

294. Colloid Chemistry Laboratory. An application in the laboratory of the principles of colloid chemistry. Laboratory work. *Must be preceded or accompanied by Chem. 291.* Two hours credit. Spring term.

40. ECONOMICS

Professors SHARFMAN, PATON, DICKINSON, WATKINS, ELLIOTT, HABER, and PETERSON; Associate Professors FORD and HOOVER; Assistant Professor LAING; and Mr. PALMER.

Economics 53 and 54 are introductory courses designed especially for students in the College of Engineering and are prerequisites to the election by engineering students of the more advanced courses in the Department of Economics listed below. However, upperclassmen may take Economics 71, 173, and 175 without having had Economics 53 and 54. For further details with respect to these courses and for additional courses in the field of economics, consult the *Announcement* of the College of Literature, Science, and the Arts.

Students who elect any course without first completing the necessary prerequisites will be denied credit in that course.

COURSES IN ECONOMICS

53, 54. General Economics. For students of the College of Engineering, of Architecture and Design, and of other professional schools or colleges. These courses offer a general survey of economic principles and problems, with primary emphasis on the latter during the spring term. Students successfully completing these courses will be admitted to advanced study in economics. Economics 53 is a prerequisite to Economics 54. *Not open to freshmen.* Three hours credit each. Fall and spring terms.

71, 72. Accounting. The concepts and procedures of accounting from the standpoint of investors and business management are emphasized. Economics 71 is a prerequisite to Economics 72. *Not open to freshmen.* Three hours credit each. Fall and spring terms.

101, 102. **Money and Credit.** A survey course dealing with the nature and functions of money and credit and giving attention to commercial banking, central banking and Treasury policies, the foreign exchanges, and current problems of monetary management and reform. *Prerequisites: Economics 53 and 54. Economics 101 is a prerequisite to Economics 102.* Three hours credit each. Economics 101, fall and spring terms; Economics 102, spring term.

121. **Labor I.** Introductory course dealing with background and development of the American labor movement. Considers problems of workers and labor unrest, including insecurity, wages, and collective bargaining. Appraises possible remedies by employers, unions, and the government. *Prerequisites: Economics 53 and 54.* Three hours credit. Fall and spring terms.

122. **Labor II.** Considers employers, unions, and the government as possible agents to deal with problems raised in the preceding course, with emphasis on trade union history, organization, and policies and on labor legislation. *Prerequisite: Economics 121.* Three hours credit. Spring term.

123. **Social Security I.** Surveys the economic basis for social insurance; the national income and its distribution; the problems of unemployment, old age dependency, illness and other causes of loss or inadequacy of income. Considers the development and significance of the social insurance movement in the United States and compares American experience with foreign social insurance measures. *Prerequisites: Economics 121 and 122.* Three hours credit. Fall term.

124. **Social Security II.** Social insurance legislation, especially unemployment compensation laws, old age, illness, disability, and survivor insurance. Economic, actuarial, and administrative problems. *Prerequisites: Economics 123 or 121 and 122 and permission of the instructor.* Three hours credit. Spring term.

131. **Corporations.** A study of large enterprises and especially of the corporate form of organization and corporation financing, with emphasis on the public interest therein and on government policies. *Prerequisites: Economics 53 and 54.* Three hours credit. Fall term.

133. **Railroad Regulation.** Deals primarily with the nature and problems of the railroad industry from the standpoint of government regulation, but is also concerned with the fundamental issues involved in the more general field of public control of industry. *Prerequisites: Economics 53 and 54.* Three hours credit. Fall term.

134. **Public Utility Regulation.** Deals primarily with the nature and problems of the so-called public utilities from the stand-

point of government regulation, but is also concerned with the fundamental issues involved in the more general field of public control of industry. *Prerequisites: Economics 133 or 131.* Three hours credit. Spring term.

153. **Modern Economic Society.** A general survey of economic principles and their applications, particularly to economic problems of war. *For seniors and graduates who have had no course in economics. Does not admit to advanced courses.* Three hours credit. Fall and spring terms.

173. **Fundamentals of Accounting.** A survey course which emphasizes cost determination and financial statements. Three hours credit. Fall and spring terms.

175. **Elementary Economic Statistics.** An introduction to the principal methods of statistical analysis as applied to economic problems. About half of the work consists of laboratory practice. *Not open to freshmen.* Three hours credit. Fall and spring terms.

181. **Public Finance.** A study of the principles and problems of governmental finance—federal, state, and local. Attention is directed to an analysis of federal and state fiscal policies, the shifting and incidence of taxation, and the economic effects of public expenditures and indebtedness. *Prerequisites: Economics 53 and 54.* Three hours credit. Fall term.

41. ENGLISH

Professors Brandt, Thornton, and Burklund; Associate Professors Wenger, Dahlström, Brackett, Walton, and Egly; Mr. Mack, Mr. Senseman, Mr. Britton, Mr. Cooke, and Mr. McEwen.

The work in English aims to prepare the student to speak and write effectively, and to give him a genuine interest in reading as a means of enlarging his fund of ideas and enriching his background. Throughout his four years he is therefore afforded a liberal choice of courses in composition, both written and oral, and of courses in the appreciation and critical reading of literature.

General Requirements.— All students of the College of Engineering are required to take ten hours of English. Regularly, they will take English 1 and 2 in their first term, and English 3 in their second term with one of the two-hour courses listed in Group II. In addition to this they must take, in their junior or senior year, a two-hour course chosen from Group III. Students in civil engineering must take English 6 for their upperclass requirement.

Any student who fails to maintain a satisfactory standard of English in any course in the College of Engineering shall be reported to the office of the Assistant Dean. The Assistant Dean shall refer the case to the Department of English for study and recommendation.

The report of the department shall be made to a special committee composed of the Assistant Dean, the chairman of the student's department of specialization, and the chairman of the Department of English. This committee may require the student to elect further work in English or may prescribe such other study as shall be deemed necessary.

Grouping of Courses.—Groups I and II include courses which satisfy the freshman requirement. Group II offers, also, nontechnical electives in public speaking, composition, and contemporary literature to all students who have satisfied the freshman requirement. Group III offers courses to satisfy the upperclass requirement. Junior, senior, and graduate students may also take courses in this group as nontechnical electives.

Library Facilities.—The English Department has a special collection of several thousand volumes, which is at present located in the Chemical Engineering Library on the third floor of the East Engineering Building.

COURSES IN ENGLISH

Group I

English 1, 2, and 3 are required of all engineering students. English 1 and 2 should be taken in the student's first term, English 3 in his second term.

1. **Theme Writing.** An introductory course in composition and the study of literature. Prepared themes; frequent impromptus; readings in essays, prose fiction, drama, and poetry. *This course is a prerequisite for all courses in English except English 2.* Three hours credit. Each term.

2. **Oral Exposition.** A practice course in public speaking which must be taken with English 1. Written outlines, extemporaneous and impromptu speaking, informal debates, and other oral exercises. Two hours of class work. One hour credit. Each term.

3. **Expository Writing.** A continuation of English 1 with special emphasis on the longer composition. *Prerequisites: English 1 and 2.* Two hours credit. Each term.

Group II

One of these courses must be elected to complete the freshman requirement; the others give credit as nontechnical electives. Except for English 4 and 5, in which the work is of a specialized nature, three to five papers, besides impromptus, are required. *Prerequisites: English 1 and 2.*

4. **Public Speaking for Engineers.** A study of the problems of organization, illustration, and effective presentation in public

address, affording frequent opportunity for practice and class criticism. Two hours credit.

5. **The Scientific and Technical Lecture.** The preparation and delivery of lectures on scientific subjects intended for scientific societies or for popular assemblies; presentation of technical reports and demonstration methods. Two hours credit.

8. **Advanced Composition.** A course for students who desire special practice in the various forms of composition. Two hours credit.

19. **Contemporary Poetry.** A survey of the principal British and American poets of the twentieth century. Readings, lectures, and discussions. Two hours credit.

20. **Contemporary Literature.** Readings in contemporary prose fiction, drama, and poetry. Two hours credit.

21. **Contemporary Drama.** A study of representative dramas from Ibsen to the present day. Two hours credit.

22. **Contemporary Novel.** Reading and discussion of outstanding European and American novels from about 1890 to the present. Two hours credit.

23. **The Short Story.** Reading and analysis of short stories from the nineteenth and twentieth centuries. Two hours credit.

GROUP III

These courses are open to juniors, seniors, and graduate students only. They may be taken for graduate credit, provided that the student has the approval of his department of specialization and that he complete additional work. Except for English 6, there is a requirement of four to six prepared papers besides impromptus. *Prerequisites: English 1, 2, and 3, and one course in Group II.*

6. **The Technical Report.** Written and oral exercises, the major assignments to be correlated as closely as possible with the technical work of the student. *Open to seniors and graduates only.* Two hours credit.

7. **Argumentation and Debate.** Study of problems most commonly met by engineers in furthering their projects; emphasis on clear, logical thinking and convincing argument; frequent opportunity for extemporaneous presentation of material. Two hours credit.

24. **The Professional Student and His Reading.** Studies in literature in relation to philosophy and the social sciences. Two hours credit.

25. **The Drama.** An appreciative study of significant dramas in classical and western civilizations. Two hours credit.

26. **The Novel.** Reading and discussion of major works in the prose fiction of the eighteenth and nineteenth centuries. Two hours credit.

27. **The Literature of Science.** Review of the writings of eminent scientists—ancient, modern, and contemporary. Two hours credit.

28. **American Literature.** Readings in the works of representative leaders in American thought. Two hours credit.

29. **Literary Masterpieces.** Studies in the works of exceptional merit in the various literary forms. Two hours credit.

30. **Shakespeare.** A study of eight of the principal plays. Two hours credit.

42. FORESTRY AND CONSERVATION

Professors DANA, MATTHEWS, ALLEN, GRAHAM, RAMSDELL, YOUNG, and KYNOCH; Associate Professors R. CRAIG, BAXTER, and O'ROKE; Forest Manager MURRAY; Instructor PATRONSKY.

All forestry courses are given in the Natural Science Building or in the Utilization Laboratory.

COURSES IN FORESTRY

31. **Introduction to Forestry.** Economic and social importance of forestry; character, distribution, management, and utilization of our timber resources; influence of forests on climate, stream flow, and erosion; forestry as a profession. Three hours credit. Spring term.

101. **Dendrology.** Classification, identification, characteristics, and distribution of the more important forest trees of the United States. *Prerequisite: systematic botany.* Three hours credit. Fall term.

128. **Pathology of Wood.** Recognition and control of the important agents which cause decay and stain in wood and wood products. *Prerequisites: Botany 1 and Forestry 162.* Three hours credit. Spring term.

130. **Forest Entomology.** Characteristics, life histories, types of injury, and control of insects attacking forest trees and forest products. Three hours credit. Fall term.

154. **Logging and Milling.** Methods and costs of logging and of lumber manufacture. Three hours credit. Spring term.

159. **Wood-Using Industries.** Requirements, processes, and products of the major wood-using industries of the United States. Three hours credit. Fall term.

160. **Tools of the Wood-Using Industries.** Character and use of the principal tools, both hand and machine, employed in the wood-using industries. Two hours credit. Fall term.

161. **Machinability of Wood.** Action of cutting edges on wood in the process of machining and power required for their efficient use. *Prerequisite: Forestry 160.* Two hours credit. Summer and fall terms.

162. **Structure and Properties of Woods.** Structure, identification, properties, and uses of North American woods. Four hours credit. Fall term.

165. **Conditioning and Preservative Treatment of Woods.** Air seasoning, kiln drying, and preservative treatment of woods. *Prerequisite: Forestry 162.* Four hours credit. Summer and fall terms.

166. **Timber Mechanics.** Mechanical properties of woods and practical application of strength data. *Prerequisite: Forestry 162.* Two hours credit. Spring term.

168. **Chemical Utilization of Woods.** Utilization of woods for the making of pulp and paper, artificial silk, and other cellulose products, and for distillation and miscellaneous products. *Prerequisites: Forestry 162 and Chemistry 4 or 5.* Two hours credit. Spring term.

170. **Lumber Grading and Specifications.** American Lumber Standards and their application, including actual practice in lumber grading and identification. *Prerequisite: Forestry 162.* Three hours credit. Spring term.

172. **Plywood and Laminated Construction.** Manufacture, properties, and utilization of plywood. *Prerequisite: Forestry 162.* Three hours credit. Spring term.

174. **Design and Construction of Containers.** Kinds, characteristics, and handling of materials used in containers. Principles of container design and construction. *Prerequisite: Forestry* 162. Two hours credit. Spring term.

176. **Forest Economics.** Economic principles and problems involved in the handling of forest lands and in the utilization and distribution of forest products. *Prerequisites: Economics 51, 53, or 153.* Three hours credit. Spring term.

182. **Foundations of Forest Management.** Preparation and

revision of forest working plans. *Prerequisite: Forestry 115.* Three hours credit. Spring term.

183. **Forest Valuation.** Methods of appraising the value of forest properties; appraisal of damages; forest taxation and insurance; determination of the right use of land. *Prerequisite: Forestry 182.* Three hours credit. Summer and fall terms.

185. **Forest Industry Economy.** Economy in productive enterprise; measuring the output of men and machines; bonus, task, and piece rate systems of payment; planning for minimum cost in logging operations. Three hours credit. Fall term.

191. **Forest and Land Policy.** Development of federal, state, and private forest policies; forest resources and products, and their place in the economic and social life of the nation. Three hours credit. Fall term.

194. **Conservation of Natural Resources.** Natural resources of the United States in soil, forests, minerals, and water; their contribution to the economic and social development of the country. Three hours credit. Fall term.

43. GEOLOGY

Professors Landes, Scott, and Lovering; Associate Professors Hussey, G. M. Ehlers, Kellum, Belknap, and Eardley; Assistant Professors Senstius and Stanley; Dr. Wilson, Dr. Gregory, and others.

The Department of Geology is located in the Natural Science Building, occupying the northern half of the eastern front and extending through the four floors of the building.

COURSES IN GEOLOGY

11. **Introductory Geology.** A general course leading to an understanding of the principles of physical and structural geology, required of students of civil engineering and geodesy and surveying, and open to others as an elective. Lectures, recitations, laboratory, and excursions. Four hours credit. Each term.

For other courses in geology to which students of engineering are eligible, see the *Announcement* of the College of Literature, Science, and the Arts. It is suggested that Geology 12 (Historical Geology), 131 (Soil Geology), and 40 and 43 (Economic Geology) are especially useful courses for engineering students.

Summer Session

Geology 11 will be given at Camp Davis, Wyoming, starting with the summer of 1942. This course will run for four weeks and will follow immediately after the close of the courses in geodesy and surveying given by the Department of Civil Engineering. (The dates for Geology 11, in 1942, are August 7 to September 4.) Also given at Camp Davis are Geology 73 and other courses in field geology.

Two courses in physiography, Geology 122 and 171, will be given during the summer session at Ann Arbor.

Summer Term

Geology 11, 12, 40, and 65 will normally be given during the summer term.

44. MECHANISM AND ENGINEERING DRAWING

Professor Miller; Associate Professors Finch, Palmer, and Hobart; Assistant Professors Potts, Bukovsky, Clark, Cole, Eichelberger, Orbeck, Smith, Schruben, and Lake.

The subjects of Engineering Drawing 1, 2, and 3 comprise the total course in engineering drawing in the four-year curriculum. The content of these three subjects has been arranged to include elementary engineering drawing and descriptive geometry. The emphasis is on the language of drawing because there is not sufficient time available in the four-year curriculum to master both the language and the art. Furthermore, the art of drawing has become subordinated to the language in modern production methods and procedures in design. It is a thorough mastery of the language of drawing which the engineering student requires for his courses in design, laboratory demonstrations, and later professional service.

COURSES IN ENGINEERING DRAWING

1. **Elementary Engineering Drawing.** The principles of orthographic projection; practice in the making of working drawings; correct drafting-room practice in conventional representation; the use of instruments; practice in lettering: freehand for dimensions and notes, and mechanical for titles; reading and checking of drawings; drill on geometric constructions; instruction on blue and brown printing; practice in tracing; original drawing on tracing papers. Three two-hour drafting-room periods, three hours homework a week. Three hours credit. Each term.

2. **Descriptive Geometry.** Has been outlined and the problems chosen to accomplish the principal purpose of developing working facility in solving the five principal and basic geometrical problems of engineering. These are determination of any and all problems of distances, all problems of angles, all problems of intersection of any line with any surface, all problems of intersection of surfaces, and all problems of plane dimensions, areas, and patterns of developable surfaces. Since no other subject in the engineering curricula gives instruction on the methods of solving these vital problems of all engineering design it has been felt wise to shape the subject of this course to the purpose. The subject covers at the same time, however, the principles of engineering descriptions of engineering proj-

ects. Three two-hour drafting-room periods, three hours homework a week. *Prerequisites: Solid Geom. and Eng. Draw. 1.* Three hours credit. Each term.

3. **Advanced Engineering Drawing.** Instruction includes engineering sketching of models in orthographic, isometric, and oblique projection; practice in the making of working drawings from sketches; sketching of engineering ideas and plans; the principles of land plats, contours, and profiles; the principles of graphical presentation of facts; structural drafting; practice in reading of drawings by analysis of structures. Two two-hour drafting-room periods, two hours homework a week. *Prerequisites: Eng. Draw. 1 and 2.* Two hours credit. Each term.

11. **Engineering Drawing.** Elementary drawing for forestry students. Use of instruments, geometric constructions, lettering practice, orthographic projection, dimensioning, and elementary working drawings. Drawing assignments are taken as far as possible from subject material with which the forestry student will later have contact. One three-hour drawing period a week. One hour credit. Spring term.

12. **Graphical Presentation and Computation.** Analysis of the construction and use of charts. Study of the purpose, scope, and use of chart forms with reference to the presentation of specific data. Construction and use of computing charts, including nomographs. Two-hour period to be arranged. *Prerequisites: Eng. Draw. 1, 2, and 3.* Two hours credit. Each term.

45. METAL PROCESSING

Professor Boston; Associate Professor Gilbert; Assistant Professors Colwell and Spindler; Mr. Gauthier, Mr. Truckenmiller, Mr. Lissell, Mr. Telfer, Mr. Grennan, and Mr. Parker.

The object of the courses in metal processing is to acquaint engineering students with fundamental principles, modern methods, and industrial applications relating to all phases of metal processing. Metallurgy, design, and methods of fabricating materials are correlated with manufacturing processes.

The Metal Processing Laboratories occupy four floors in the south wing of the East Engineering Building. Classrooms and locker rooms are arranged adjacent to the laboratories. An electric freight elevator serves all floors. Materials, such as sands, refractories, smithing coal, coke, iron and steel scrap, and pig iron are stored in bins under the court of the building.

The Machine Tool Laboratory, 60 by 130 feet, is on the first floor and has been carefully arranged to demonstrate the two types of machine-shop methods, toolroom and production. One part of the laboratory contains one or more of each of the principal types of machine tools used in toolrooms. In another part of the laboratory, the machines are arranged to give the student a perspective of the machines, tools, and methods used in the manufacture of articles in production.

The Machinability Laboratory, on the second floor, contains drill presses, lathes, and millers equipped with dynamometers, potentiometers, wattmeters, and special instruments to study problems of machinability and metal cutting. Equipment for metallographic work, hardness inspection, surface finish studies, and vibration testing is also available.

The Design Room on the second floor will accommodate twenty students majoring in die design, machine tool design, and other phases of tool engineering.

The University Instrument Shop, on the second floor at the east end, is equipped for fine instrument work. Research apparatus for the University is constructed. This work is handled by a permanent staff of instrument makers and is independent of instruction given to students.

The Working, Treating, and Welding Laboratory, 60 by 100 feet, on the third floor, is equipped with a wide variety of machines and equipment used in forging, welding, brazing, heat-treating, and testing steel.

The Foundry Laboratory, 60 by 130 feet, on the fourth floor, is divided into the melting, molding, coremaking, testing, and cleaning divisions. Cleaning equipment, and equipment such as melting furnaces, core racks and ovens, and benches are available; also sand-testing and core-testing machines for routine instruction and research.

The Gaging and Measuring Laboratory, 36 by 24 feet, is located in Room 2311 on the second floor, south wing of the East Engineering Building. This laboratory contains equipment to illustrate the use, operation, and design of measuring and gaging instruments. Measuring and gaging devices are available for making measurements of forms, angles, and sizes. Surface plates, projectors, comparators, standard centers, master blocks, sine-bar fixtures, microscopes, and other standards and accurate measuring devices complete the equipment for high-quality work.

COURSES IN METAL PROCESSING

2. **The Working, Treating, and Welding of Steel** is an introductory study of the principles and practice relating to the processing, properties, and application of wrought-steel products. Melting practice in relation to the classification and specifications for steel is considered. The effects of mechanical working, heat-treating, and welding on the microstructure and physical properties of carbon and alloy con-

structional and tool steels are studied in the classroom and evaluated in the laboratory. One recitation and one three-hour laboratory period a week. *Must be accompanied by Chem. Eng. 1.* Two hours credit.

3. **Foundry.** A study of the principles and practice relating to the production of gray iron, malleable iron, steel, brass, bronze and aluminum castings and their application. The constitution and properties of molding sands, core sands, and metal are considered in detail. Principles of design, risering, and gating also are discussed. Attention is given to the design, production, welding, and heat-treatment of castings. Two recitations and two three-hour laboratory periods a week. *Prerequisite: Metal Proc. 2.* Four hours credit.

4. **Machine Shop.** Planned to give a student a clear conception of the relation between design, fabricated form and type of material, and manufacturing processes used in the production of parts in small, intermediate, and large quantities. Studies are made of all types of metal cutting and forming operations and their machines, tools, and accessories. Two recitations and two three-hour laboratory periods a week. *Prerequisites: Metal Proc. 2 and Eng. Mech. 2.* Four hours credit.

5. **Welding.** Gas, arc, resistance, atomic hydrogen, and thermit welding; oxygen and arc cutting; manual and automatic procedures; metallurgy of welds in ferrous and nonferrous metals, and all phases of the economics and application of welding are studied. One lecture and one three-hour laboratory period a week. *Prerequisite: permission of the instructor.* Two hours credit.

8. **Foundry Costs and Organizations.** A study of foundry costs methods, foundry records, and standard instructions for foundry operations. Lectures and assignments. *Prerequisite: Metal Proc. 3.* Two hours credit.

9. **Foundry.** This is a study of the melting, molding, coremaking, and cleaning divisions of foundry practice; of the manufacturing processes used in the production of gray iron, malleable iron, steel, and the nonferrous alloys; of the constitution and properties of the different cast metals; and of the methods used in controlling the operations in the foundry. For students pursuing metallurgical engineering. One hour in the classroom and three hours in the laboratory each week. Two hours credit.

10. **Measuring and Gaging.** Standards of measurement, mechanical dimensional control, and equipment and methods used in measuring and gaging in manufacture are studied. The facilities of the Measuring and Gaging Laboratory are available for practice. *Prerequisite: Metal Proc. 4.* Two hours credit.

12. **Advanced Working, Treating, and Welding of Steel.** Further work on these subjects may be elected by making arrangements with the instructor. *Prerequisite: Met. Eng. 3 or 7.* Work in the field of welding should also be preceded by Metal Proc. 5.

13. **Advanced Foundry.** For those students who are especially interested in the foundry branch of engineering, advanced foundry instruction is offered on special problems. Arrangements are to be made with the instructor.

14. **Advanced Machine Shop.** For correlating design and production, students may, working separately or in groups, prepare complete manufacturing drawings of a device, carefully select the type and form of material for each part, and then actually construct it. Arrangements are to be made with the instructor. *Prerequisite: Metal Proc. 4.* Two or more hours credit.

107. **Metal Stamping, Die Casting, and Plastic Molding.** The characteristics and properties of products manufactured by metal-stamping, die-casting, and plastic-molding processes are studied. These processes constitute an important supplement to the machining processes for large-quantity production of mechanical goods. Emphasis is placed on the processing, comparison of materials, the design of the product as affected by the characteristics of the process, and relative costs. Two lectures and one three-hour design period per week. *Prerequisite: Metal Proc. 4.* Two hours credit.

108. **Jigs, Fixtures, and Machining Tools.** A study is made of factors involved in large-quantity production by the machining processes. Machine tools and their uses, the application of theories of machinability to cutting practice, and the design of jigs, fixtures, and small tools are reviewed. Preliminary design computations and cost estimates are made. Two lectures and one three-hour design period per week. *Prerequisites: Metal Proc. 3 and 4; Metal Proc. 10 is desirable.* Two hours credit.

109. **Machinability.** Advanced studies are made of metal cutting from theoretical and practical viewpoints. Reference reading and laboratory experiments are carried out. Experimental data are compiled into charts, slide rules, and mathematical equations so as to be of value in practice. *Prerequisite: Metal Proc. 4.* Two or more hours credit.

110. **Materials for Aircraft Construction** (Aero. Eng. 17). Designed for aeronautical engineering students to acquaint them with materials used in the design of aircraft. Numerous materials are studied as to their costs, physical and chemical properties, and the thermal and chemical treatment best suited for resistance to corrosion, high strength-weight ratio, and ease of processing. One class and one three-hour laboratory period each week. *Prerequisites: Metal Proc. 4 and Aero. Eng. 5.* Two hours credit.

46. MILITARY SCIENCE AND TACTICS

Professor Ganoe; Assistant Professors Egger, Renner, Houston, Bulmer, Vollrath, Kolb, Peterson, and Lohla.

Courses in military science and tactics are offered to physically fit male students who are citizens of the United States. Students electing courses in this department are not required to elect physical education. These courses are designed to give thorough groundwork in military subjects considered necessary as a part of the education of a commissioned officer.

The courses of the first four terms comprise the basic group, and the courses of the next four terms comprise the advanced group. While taking the advanced group, members of the Reserve Officers' Training Corps receive pay from the Government, which amounts to about $200.00.

A deposit of $14.00 to cover property responsibility is required of each basic student. This deposit is returned at the completion of the basic course. The uniform furnished remains the property of the government and must be returned.

A deposit of $12.50 is required of each advanced-course student. This deposit is returned at the completion of the advanced course and the officer's uniform furnished remains the property of the government and must be returned.

Academic credit is given for R.O.T.C. training.

Consultation Hours.—During registration period, 9 a.m. to 12 m. and 1 to 4 p.m. daily, at the Department Office.

Rifle Practice.—All R.O.T.C. students are eligible to compete for the rifle team. Membership on the R.O.T.C. Rifle Team depends on both excellence in marksmanship and compliance with the rules governing attendance at practice and competitions. Hours of practice to be announced.

Courses leading to reserve commissions in the following branches of the Army are offered:

Infantry.—Theoretical and practical work which will enable a student to understand and make proper use of infantry weapons and handle a company of infantry according to modern tactical principles. Open to all students.

Ordnance.—Theoretical and practical work in the design, manufacture, inspection, and test of guns, ammunition, bombs, tanks, etc. In view of the fact that the Ordnance Department is a technical and manufacturing branch of the Army, a student during the advanced course takes certain technical subjects in his own college which tend to make him more of a specialist in his own line, and, therefore, of more value to the Ordnance Department. Open to engineering students.

Signal Corps.—Theoretical and practical work which will enable a student to apply his engineering knowledge to military communications. Open to students of the College of Engineering, particularly electrical engineers, and others interested in electrical communications.

Military Engineering.—Theoretical and practical work which will enable a student to apply his engineering knowledge to military work and to handle an engineer company in combat. Open to students in the College of Engineering, in architectural design, and in Architecture Program I.

Upon election of a particular branch of engineering, R.O.T.C. students previously enrolled in an inappropriate unit may transfer to the unit to which their engineering department election makes them eligible, without loss of credit.

MILITARY SCIENCE AND TACTICS

Program

	Inf.	*Ord.*	*Sig. Corps*	*Engrs.*
1st Term	M.S. 1	M.S. 1	M.S. 1	M.S. 1
2d Term	M.S. 2	M.S. 2	M.S. 2	M.S. 2
3d Term	M.S. 63	M.S. 63	M.S. 43	M.S. 63
4th Term	M.S. 64	M.S. 64	M.S. 44	M.S. 64
5th Term	M.S. 115	M.S. 35	M.S. 45	M.S. 55
6th Term	M.S. 116	M.S. 36	M.S. 46	M.S. 56
7th Term	M.S. 117	M.P. 10	M.S. 47	M.S. 57
8th Term	M.S. 118	M.S. 38	Elec. Engr's. E.E. 10, or E.E. 22	M.S. 58
		Consult with Ordnance Officer about electives.		

Infantry Drill: Two hours of drill per week is required with every course in military science and tactics. Drill is used merely as a vehicle for laboratory practice in leadership, every responsibility being placed upon cadet officers.

R.O.T.C. graduates of senior units who will, in 1942-43, have completed all scholastic requirements for a commission, will attend the basic course in the appropriate special service school following graduation. Upon satisfactorily completing this course, they will be appointed second lieutenants in the ORC.

Summer 1942, and alternate terms, odd-numbered courses are offered. Fall 1942, and alternate terms, even-numbered courses are offered.

COURSES IN MILITARY SCIENCE

Basic Courses

1. **Military Fundamentals, Rifle Marksmanship, and Command and Leadership.** One hour credit.

2. **Military Fundamentals, Characteristics of Infantry Weapons, Map Reading, and Command and Leadership.** One hour credit.

63. **Aerial Photograph Reading, Scouting and Patrolling, Automatic Rifle, and Command and Leadership.** One hour credit.

64. **Technique of Rifle Fire, Sketching, Combat Principles, and Command and Leadership.** One hour credit.

INFANTRY COURSES

115. **Machine Guns, Command and Leadership, 37 mm. Gun, 81 mm. Mortar, and Pistol Marksmanship.** Two hours credit.

116. **Combat Principles, Field Fortification, and Rifle Marksmanship.** Two hours credit.

117. **Military Law, Mess Management, and Tactics.** Two hours credit.

118. **Military History and Policy, Administration, and Tactics.** Two hours credit.

ORDNANCE COURSES

35. **Ordnance Materiel, Organization of the Ordnance Department, Mess Management, and Military Law.** Two hours credit.

36. **Ordnance Ammunition, District Organization, Administration, and Military History.** Two hours credit.

37. **M.P. 10 required.** Two hours credit.

38. **Ordnance Supply.** One hour credit.

SIGNAL CORPS COURSES

43. **Signal Corps Organization, Signal Communication for All Arms and Services, Wire Signal Communication System, and Map and Aerial Photograph Reading.** One hour credit.

44. **Aerial Photograph Sketching, Field Radio Sets, Field Radio Communication Systems, and Code Practice.** One hour credit.

45. **Military Law, Mess Management, Signal Communication Tactics, Signal Company Combat Orders, Message Center Procedure, and Code Practice.** Two hours credit.

46. **Military History and Policy, Advanced Signal Communication, Administration, Homing Pigeons, and Code Practice.** Two hours credit.

47. Military Cryptography, Advanced Signal Communication, Motor Transport Maintenance, Signal Supply, and Training Management. Two hours credit.

ENGINEER COURSES

55. Field Fortifications, Rigging, Combat Principles, Engineers, and Command and Leadership. Two hours credit.

56. Military Bridges, Explosives and Demolitions, and Command and Leadership. Two hours credit.

57. Military Law, Mess Management, Organization of the Ground for Defense, Military Roads, and Tactics and Technique of Engineers. Two hours credit.

58. Military History and Policy, Administration, Map Making, and Employment of Engineer Platoon and Company on Engineer Work. Two hours credit.

47. MINERALOGY AND PETROGRAPHY

Professors HUNT and PECK; Associate Professors RAMSDELL and SLAWSON.

The Mineralogical Laboratory comprises thirty-six rooms located in the northwest portion of the Natural Science Building.

The laboratory is well equipped with crystal models, natural crystals, and lecture and working collections of minerals, rocks, and thin sections. There is an excellent equipment of goniometers, polarization microscopes, and other crystallographic-optical instruments necessary for the thorough study of minerals. The department is equipped with a platinum-resistance quenching furnace for the investigation of silicate meltz. Likewise facilities for x-ray study of crystal structure are available, including the Weissenberg goniometer. The blowpipe and chemical laboratories possess every facility for the qualitative and quantitative determination of minerals and rocks. The equipment of the laboratory is such that special attention can be given to graduate work and special investigations in mineralogy, crystallography, and petrography.

COURSES IN MINERALOGY

31. Elements of Mineralogy. Includes the elements of crystallography, and the physical and chemical properties, occurrence, uses, and determination of the more common minerals. Three lectures and two hours of laboratory a week. *Prerequisite: a knowledge of elementary inorganic chemistry*. Three hours credit. Fall and spring terms; summer term if demanded.

94 (104). Useful Minerals, Building and Decorative Stones. Designed primarily for students of architecture and engineering. The first half of the course treats of the properties and uses of the common minerals and ores; the second half is devoted to a discussion of rocks. Three lectures and two hours of laboratory work a week. *Prerequisite: a knowledge of elementary inorganic chemistry.* Three hours credit. Spring term.

99 (109). Elements of Crystallography. Covers crystallography, crystal projections, and the underlying principles of crystal structure. Designed primarily for students in metallurgical engineering. Lecture and laboratory work. One hour credit. Fall term.

151 (152). Optical Crystallography. Detailed discussions of the behavior of crystals in polarized light. In the laboratory, applications to the examination of nonmetallic crystalline substances by means of the polarizing microscope and other crystallographic optical instruments will be stressed. *Prerequisite: permission of the instructor.* Three hours credit. Fall term.

For full information about the courses in mineralogy, see the *Announcement* of the College of Literature, Science, and the Arts.

48. MODERN LANGUAGES

The study of a modern foreign language is considered of particular value to the student in the technical school, as it serves to broaden his outlook on life by introducing him to a new literature and a new civilization. With such an asset of a cultural and social nature added to his practical training, the student should represent the ideal type of university man, possessing a well-rounded and complete education beneficial both to himself and to society.

The aim of the instruction in French, German, and Spanish is to help the student to a reading, writing, and speaking knowledge of those languages. The object of the courses of the first two years is to familiarize the student with the forms and the construction of the languages and to furnish him with practice in reading and speaking them.

The object of the courses of reading in scientific literature is to acquaint the student with the terminology and special vocabularies of the various sciences, and thus enable him to consult books and periodicals bearing on his professional work with facility and profit. Many students read, besides the work assigned for the classroom, scientific articles in the numerous foreign periodicals to be found in the Engineering Library. These are of value to the student in the pursuit of much of his advanced work.

Students in aeronautical engineering are advised to elect German; and students in astronomy, mathematics, and physics are advised to elect both French and German. Students who expect to do graduate work in chemical engineering are urged to acquire a reading knowledge of German.

Elective courses of two types are offered: (1) advanced courses in the language studied for those who wish to pursue work beyond actual requirements; (2) general courses in foreign literatures for cultural purposes.

FRENCH

1. **Elementary French.** Pronunciation. Understanding of grammatical constructions. Easy reading. Daily oral practice. Composition work is deferred. Four hours credit. Each term.

2. **Elementary French, Continued.** Continued oral practice. Reading. Grammar accompanied by exercises and easy composition. Conducted partly in French. *Prerequisite: French 1, or equivalent.* Four hours credit. Each term.

31. **Second-Year French.** Careful reading and study of representative modern prose. Review and application of the essential principles of grammar by means of oral and written exercises and some composition. Continued practice in pronunciation and in hearing the spoken language; some conversation. Outside reading intended to develop the ability to read rapidly at sight. Conducted in French as far as possible. *Prerequisite: French 2, or a two-year course in high school.* Four hours credit. Each term.

32. **Second-Year French, Continued.** French 32 may be followed by any or all of the courses, French 91 (four hours credit), 93 (three hours credit), 161 (two hours credit), or 83 (two hours credit). *Prerequisite: French 31, or a three-year course in high school.* Four hours credit. Each term.

51 (11). **First Special-Reading Course.** The main aim of this course is the acquisition of the ability to read French. An outline survey of the grammar precedes study of several simple reading texts. *French 51 is designed for upperclassmen who do not intend to continue more than two or three terms. Underclassmen may elect this course only by special permission of the Department. Graduate students wishing to do the work of this course should enroll early through the College, as the sections are limited in size.* Four hours credit. First term.

52 (12). **Second Special-Reading Course.** Careful reading and study of a series of graded texts constitute the work of this course, which presupposes such linguistic skill as may be attained in French 51 or its equivalent. *French 52 is for upperclassmen. Underclassmen may elect it only by special permission. Graduate students wishing to do the work of this course should enroll early through the College, as the sections are limited in size.* French 52 may be followed by French 53. Four hours credit. Second term.

For advanced elective courses, consult the *Announcement* of the College of Literature, Science, and the Arts.

GERMAN

1. **Elementary German.** A study of the essentials of the grammar, with practice in reading and writing German. Four hours credit. Each term.

2. **Elementary German.** Continuation of German 1 (or of its equivalent, one year of high-school German). Pronunciation, grammar, easy readings, with practice in speaking and writing German. Four hours credit. Each term.

For advanced elective courses consult the *Announcement* of the College of Literature, Science, and the Arts.

11. **First Special Elementary Course.** A brief study of the essentials of grammar followed by the reading of suitable graded texts. *This course is specifically designed for and open only to seniors who are primarily interested in acquiring a rapid reading knowledge of German. Graduate students wishing to attend the course should enroll early through the College, as this section will be limited in size.* Three hours credit. First term.

12. **Second Special Elementary Course.** Careful reading and study of a series of texts best suited to the specific needs of the class. *Prerequisite: German 11 or its equivalent.* Three hours credit. Second term.

31. **Second-Year German.** German prose and poetry. Selected readings from representative modern prose writers. Reviews of grammar with practice in speaking and writing German. *Prerequisites: German 1 and 2 in the University, or two years of German in high school.* Four hours credit. Each term.

32. **Second-Year German.** Continuation of German 31. Selected readings from modern writers and the classic poets. Reviews of grammar with practice in speaking and writing German. *Prerequisites: German 1, 2, and 31, or three years of German in high school.* Four hours credit. Each term.

For courses in scientific German and chemical and technical German, consult the *Announcement* of the College of Literature, Science, and the Arts.

SPANISH

1. **Elementary Spanish.** Grammar, oral work, and reading. Four hours credit. Each term.

2. **Elementary Spanish.** Continuation of Spanish 1. *Prerequisite: Spanish 1, or equivalent.* Four hours credit. Each term.

31. **Second-Year Spanish.** Reading of modern texts, grammar review, and conversation. *Prerequisite: Spanish 2, or two years of high-school Spanish.* Four hours credit. Each term.

32. **Second-Year Spanish.** Continuation of Spanish 31. *Pre-*

requisite: Spanish 31 or three years of high-school Spanish. Four hours credit. Each term.

For advanced elective courses consult the *Announcement* of the College of Literature, Science, and the Arts.

Summer Session

Courses will be offered during the Summer Session.

49. NAVAL SCIENCE AND TACTICS

Professor Cassidy; Assistant Professors Shook, Pananides, Atkinson, and Brewer.

The object of the courses in naval science and tactics is to provide systematic training and instruction in essential naval subjects for a group of physically qualified and selected students, concurrently with their preparation for a civilian profession, in order that they may be qualified to serve as officers; thus assisting in meeting the demands for increased commissioned personnel of the United States Navy in event of national emergency, forwarding the plans for national defense, and training young men in the ideals of citizenship. The program of instruction is designed to foster the ideals of character essential to naval leadership, integrity, discipline, self-reliance and co-operation. The course is technical to the extent that it makes available to the student a knowledge of seamanship, ordnance, gunnery, engineering, electricity, communications, naval tactics (surface, subsurface and aerial), military law and navigation. Eight terms of academic work in naval science plus three in navigation combined with a background of naval experience, tradition, customs, and leadership acquired through drills and practical cruises at sea may qualify him on graduation, if he possesses aptitude, to receive a commission from the President of the United States, to perform the duties of an officer in the United States Naval Reserve or in the United States Marine Corps Reserve.

The course is composed of the Basic Course and the Advanced Course, plus Navigation. Once elected, completion of the Basic Course is a prerequisite to the Advanced Course, and completion of the Advanced Course and Navigation is a prerequisite to graduation unless the student is formally discharged from the obligation. The Basic Course, Naval Science 21, 22, 31, and 32, requires three hours work per week, two in classroom and one at drill for which four semester hours of credit are allowed. The Advanced Course, Naval Science 41*a*, 42*a*, 51*a*, *and* 52*a*, arranged for students whose courses in the College of Engineering are approved by the Professor of Naval Science and Tactics, requires three hours work per week, two hours in classroom and one at drill, except that in the eighth term four hours per week is required, for which eight semester hours credit are allowed. Students not taking approved courses in engineering and electricity will elect Naval Science 41, 42, 51, and 52 which require four hours work per week. Navigation, Naval Science 60, 61, and

62; requires two hours work per week and may be completed in three terms if the student is adequately prepared in mathematics, including trigonometry and logarithms. Navigation is first offered in the fourth term. Six semester hours of credit are allowed.

The election of the courses in naval science and tactics by a student of engineering entails some readjustment of the type programs shown under the several professional departments of this *Announcement* in order that navigation, which is classed as a nontechnical elective, may be covered prior to the Advanced Course cruise which is taken in the summer following the junior year. These special programs will be arranged by the classifiers in the several departments.

Naval R.O.T.C. practice cruises in battleships, cruisers or destroyers are held annually during the summer, when possible. Attendance on a cruise following the junior year is a prerequisite to receiving a commission and must be considered in connection with any work planned to be taken during the University summer sessions. All Naval R.O.T.C. students are eligible and may volunteer for a cruise each summer.

Uniforms and textbooks are furnished by the Government without charge. All students attending a summer cruise are provided transportation and subsistence. Students enrolled in the Advanced Course are paid commutation of subsistence during the period of their enrollment, not to exceed two years, and cruise pay, totaling approximately $190.

In view of the selective character of the enrollment students are required to make preliminary application on a special form and appear for interview and physical examination at the Naval R.O.T.C. Headquarters, North Hall, during Orientation Period. Application forms will be mailed upon request. Evidence of citizenship must be presented and minors (under twenty-one years) must present written consent of parents or guardian to enrollment.

The Naval Unit is organized as a battalion of infantry with military drills held in the fall and spring of the year. Other drills include radio, signaling, small-bore rifle target practice and competition, pistol practice, seamanship, tactics, navigation, and service of the naval gun in preparation for firing at sea.

21. **Elementary Seamanship and Naval History.** An elementary study of Navy customs and organization; the characteristics, hull, and fittings of ships; small boats; the compass; deck and marlinspike seamanship; ground tackle; mooring; gas-protective apparatus; preservation of ships; steering and sounding; general ship drills; duties of seaman watches. A short history of the United States Navy. Two hours classroom work and one hour drill per week. One hour credit. First term.

22. **Naval Ordnance and Naval Communication.** Naval ordnance: Explosive reactions, properties of service explosives; elemen-

tary interior ballistics; guns; breech mechanisms; firing attachments; gun mounts; turret mounts; Waterbury speed gear; recoil brakes; gun sights. Naval communications: Methods of communication; naval communication service and policy; radio network; internal organizations; communication security; distress signals; the drafting of messages. Two hours classroom work and one hour drill per week. One hour credit. Second term.

31. Ordnance and Naval Communications. Ordnance: armor; projectiles; ammunition; small arms; torpedoes, mines; depth charges; aircraft bombs; chemical warfare; safety precautions. Naval communications: radio and visual procedure; flaghoist signaling; buzzer and flashing light codes, with drill. Two hours classroom work and one hour drill per week. One hour credit. Third term.

32. Seamanship. Deals with the practices of seamen; rules of the road; shiphandling; stranding and towing; damage control; collision cases; grounding cases; buoyage systems; weather and laws of storms. Two hours classroom work and one hour drill per week. One hour credit. Fourth term.

41. Minor Tactics. A continuation of communications including tactical employment and principles of naval gunnery. Marine engineering. Elementary thermodynamics, fuels and combustion, heat engines, boilers, heat transfer. *Prerequisite: Nav. Sci. 32.* Three hours classroom work and one hour drill per week. Two hours credit. Fifth term.

41a. Same as Course 41 except marine engineering is omitted. Open only to students who are taking or have satisfactorily completed Mech. Eng. 3. *Prerequisite: Nav. Sci. 32.* Two hours classroom work and one hour drill per week. Two hours credit. Fifth term.

42. Minor Tactics. Continues the principles of naval gunnery including spotting and firecontrol and the employment of aircraft; elementary aviation and the administrative duties of the junior officer Marine engineering. Main propelling machinery, auxiliaries, and the engineering department aboard ship. *Prerequisite: Nav. Sci. 41* Three hours classroom work and one hour drill per week. Two hours credit. Sixth term.

42a. Same as Course 42 except marine engineering is omitted Open only to students who are taking or have satisfactorily completed Mech. Eng. 3. *Prerequisite: Nav. Sci. 41a.* Two hours classroom work and one hour drill per week. Two hours credit. Sixth term.

51. Administration and Naval History. Deals with the organization of the naval establishment, and the influence of sea power on history. Famous naval battles are studied and presented by seminar groups. Electricity. Elementary principles of direct and alternating current machinery, shipboard circuits and general uses, searchlights, boat cranes, electric steering. *Prerequisite: Nav. Sci. 42.* Three hours classroom work and one hour drill per week. Two hours credit. Seventh term.

51a. Same as Course 51 except electricity is omitted. Open only to students taking or who have successfully completed Elec. Eng. *2a. Prerequisite: Nav. Sci. 42a.* Two hours classroom work and one hour drill per week. Two hours credit. Seventh term.

52 and 52a. Naval Leadership and the Regulations. Deals with personnel management, naval courts martial, the Navy regulations, and the principles of naval leadership. *Prerequisite: Nav. Sci. 51 or 51a.* Three hours classroom work and one hour drill per week. Two hours credit. Eighth term.

60. Geonavigation. Navigational instruments; the gyro compass; charts; barometer; compass error and its compensation; piloting; the sailings; dead reckoning; ocean currents; chronometers. *Prerequisite: plane trigonometry.* Two hours of classroom work per week. Two hours credit. Fourth term.

61. Celonavigation. Equinoctial and horizon systems; motion of sun and planets; lines of position; sextant; altitude and azimuth; time; observations for latitude; interval to noon; declination and reduction to the meridian; Saint Hilaire method; fixes; A.M. and P.M. sights; practical work. *Prerequisite: Nav. Sci. 60.* Two hours of classroom work per week. Two hours credit. Fifth term.

62. Celonavigation. Study of various short methods of navigation; day's work at sea; moon and tides; identification of stars and planets; aerial navigation; practical work and review of piloting and day's work. *Prerequisite: Nav. Sci. 61.* Two hours of classroom work per week. Two hours credit. Sixth term.

50. ENGINEERING RESEARCH

Professor A. E. White, Director; Associate Professor Good, Assistant Director; Professor Cissel, Mr. Potter, and Mr. Small, Assistants to the Director; Research Engineers Walker, Freeman, and Quinsey; Research Physicists Geiger, Vincent, Wolfe, Foley, Fowler, Kent, Koppius, and Plyer; Research Chemist Delp; Research Associates Boyd, Frederick, Johnston, Werner, Beebe, Crouch, Dick, Hadley, Horton, Jenner, McNaughton, and Rote.

The Department of Engineering Research was established in October, 1920. It affords an official channel through which the research facilities of the University in engineering and related fields of work are made available to the civic and industrial interests of the state and elsewhere. No course work is offered but many of the research projects which come to the Department afford an opportunity for students to work as assistants.

The function of the Department is largely administrative. The technical direction of researches sponsored through it is generally assigned to members of the faculty and most of the work is done in the laboratories of the instructional departments with which they are associated.

Part III

PROFESSIONAL DEPARTMENTS

The following curricula offered in the professional departments were accredited by the Engineers' Council for Professional Development, on October 1, 1937: Aeronautical, Chemical, Civil, Electrical, Marine, Mechanical, Metallurgical, and Transportation Engineering, and Engineering Mechanics and Naval Architecture.

51. THE GROUP SYSTEM OF ELECTIVE STUDIES

The system provides that of the 140 hours of credit required for graduation, about 125 hours are prescribed and 15 hours may be elective. These elections may be made from announced groups of study or from other courses approved by the head of the department.

The group system allows the student to receive his instruction in the advanced subjects from a specialist. It also permits a student desiring to take up a fifth year of study to specialize in some particular branch of engineering. A student in any group will be allowed to elect work in the other departments of engineering or in the other colleges or schools of the University, subject to the approval of the head of the department. A student desiring to obtain special scientific knowledge or special business training by building on the fundamental subjects of engineering may be allowed to elect scientific courses or courses in economics or business administration under the direction and approval of the head of his department.

Information regarding the several professional departments of the College of Engineering, facilities for instruction, requirements for graduation, schedules of study, etc., will be found in the following pages.

52. AERONAUTICAL ENGINEERING

Professors Stalker and Pawlowski; Associate Professors Conlon and Kuethe; Mr. Allen and Mr. Steinbacher.

The work in this Department has been arranged to cover all problems entering into the design and construction of machines that utilize the air as their means of support and transportation. This includes a study of general aerodynamics, the determination of stresses, and the general design of structure for all parts of an aircraft, and the design of propellers and propelling machinery.

The Courses offered by the Department are arranged to cover the essentials of aerodynamics necessary for the proper understanding of the action of wings and propellers and of problems connected with stability and maneuvering; and form the basis for the application of such studies to the design, construction, and analysis of performance of all types of aircraft.

Each student has the choice of one of two groups of study, either Group A, Airplane Structure and Design, or Group B, Aircraft Power Plants.

Preparatory courses in mathematics, theory of structures, hydromechanics, and mechanical engineering are essential. In the design of aircraft, the student is given an opportunity to apply such studies so as to obtain the best solution to any given set of conditions.

The aerodynamic and structural laboratories offer facilities for experimental work and are available for research work for advanced students.

Aeronautical Laboratories.—The Aeronautical Engineering Department has two laboratories, one devoted to aerodynamics and the other to structures.

The Aerodynamic Laboratory consists of two wind tunnels. The larger one is an open-throat, double-return type. The throat has an octagonal cross section which may be varied from five feet to eight feet. With the large diameter the maximum wind velocity is one hundred miles per hour. This tunnel is equipped with a six-component wire balance, a dynamic stability balance, and a balance incorporating the rigid-model support particularly suited to experimentation with boundary-layer control. Facilities for testing model propellers are also provided.

The smaller wind tunnel is the closed-throat, single-return type. The throat is twenty inches by thirty inches, and the tunnel has a maximum velocity of sixty miles per hour.

The Structures Laboratory is designed for testing both stressed-skin and truss-type structures. The equipment includes a drop-test apparatus for the investigation of landing-gear shock struts, optical-strain gages capable of measuring elongations of .000002 of an inch, and other special equipment.

Advice to Students of other colleges and universities, with regard to planning their courses before coming to the University, is given in Section 7.

Military and Naval Science.—The attention of prospective students in aeronautical engineering is called to the Reserve Officers' Training Corps. Students in aeronautical engineering are particularly well qualified to take the work offered in preparation for air service. Those who consider taking military or naval science are urged to enroll at the beginning of their course. For further details see sections 46 and 49.

Meteorology.—Courses in Meteorology are offered in the Department of Geology. See Section 43.

Air Navigation.—Courses in Air Navigation are offered in the Department of Astronomy and are described under Section 53.

CURRICULUM IN AERONAUTICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Aeronautical Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives	6
Economics 53, 54	6
Math. 13, 14, 53, 54, 150	20
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2 and Chem.-Met. Eng. 1	5
Total	70

b) *Secondary Courses*	
Metal Proc. 4, Machine Shop	4
Eng. Mech. 1, Statics	3
Eng. Mech. 2, 2*a*, Strength and Elasticity	5
Eng. Mech. 3, Dynamics	3
Eng. Mech. 4, Fluid Mechanics	3
Civil Eng. 2, Theory of Structures	3
Mech. Eng. 2, Elements of Machine Design	3
Mech. Eng. 3, Heat Engines	4
Mech. Eng. 5, Thermodynamics	3
Mech. Eng. 7, Laboratory	2
Mech. Eng. 15, Internal Combustion Engines	3
Elec. Eng. 2*a*, Electric Apparatus and Circuits	4
Aero. Eng. 1, General Aeronautics	3
Aero. Eng. 2, Theory of Aviation	3
Aero. Eng. 3, Theory and Design of Propellers	2
Aero. Eng. 4, Basic Airplane Structures	3
Aero. Eng. 6, Experimental Aerodynamics	1
Total	52

Summary:	*Hours*
Preparatory Courses	70
Secondary and Technical Courses	52
Group Options and Electives	18
Total	140

Group Options.—Students in aeronautical engineering may select one of the following groups of courses according to their interest:

Group A. Airplane Structure and Design	*Hours*
Aero. Eng. 5, Airplane Design	2
Aero. Eng. 23, Airplane Structures	3
Aero. Eng. 25, Advanced Airplane Performance	2
Aero. Eng. 27, Applied Aerodynamics	3
Free Electives	8
	18

Group B. Aircraft Power Plants	
Mech. Eng. 60, Aircraft Power Plants	3
Mech. Eng. 61, Experimental Tests	3
Mech. Eng. 62, Design of Aircraft Engines	2
Mech. Eng. 63, Design of Aircraft Engines	2
Free Electives	8
	18

PROGRAM

FIRST TERM		SECOND TERM	
COURSES	HRS.	COURSES	HRS.
Math. 13 (Alg. and Anal. Geom.)	4	Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 1	3	*English 3	2
*English 2	1	*English (Group II)	2
Drawing 1	3	Drawing 2	3
†Chem. 5 or Ch.-Met. 1 and Metal Proc. 2	5	†Ch.-Met. 1 and Metal Proc. 2 or Chem. 5E	5
‡Physical Ed. or Mil. or Nav. Science	0 or 1	‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17		16 or 17

THIRD TERM		FOURTH TERM	
Math. 53	4	Math. 54	4
Physics 45	5	Physics 46	5
Draw. 3	2	Eng. Mech. 2	4
Eng. Mech. 1	3	Eng. Mech. 2*a*	1
Economics 53	3	Economics 54	3
Mil. or Nav. Science	(1)	Mil. or Nav. Science	(1)
	(18) or 17		(18) or 17

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

FIFTH TERM

Math. 150	4
Mech. Eng. 3	4
Metal Proc. 4	4
Eng. Mech. 3	3
	15

SIXTH TERM

Aero. Eng. 1	3
Mech. Eng. 2	3
Civil Eng. 2	3
Elec. Eng. 2*a*	4
Mech. Eng. 7	2
	15

SEVENTH TERM

Aero. Eng. 2	3
Aero. Eng. 3	2
Eng. Mech. 4	3
Mech. Eng. 5	3
Mech. Eng. 60, Opt. B or Elective, Opt. A	3
	14

GROUP A

EIGHTH TERM

English (Group III)	2
Aero. Eng. 4	3
Aero. Eng. 25	2
Mech. Eng. 15	3
Electives, free or nontechnical	5
	15

NINTH TERM

Aero. Eng. 5	2
Aero. Eng. 6	1
Aero. Eng. 23	3
Aero. Eng. 27	3
Electives, free or nontechnical	6
	15

GROUP B

EIGHTH TERM

Aero. Eng. 4	3
Mech. Eng. 15	3
Mech. Eng. 61	3
Mech. Eng. 62	2
Electives, free or nontechnical	4
	15

NINTH TERM

English (Gr. III)	2
Aero. Eng. 6	1
Mech. Eng. 63	2
Electives, free or nontechnical	10
	15

COURSES IN AERONAUTICAL ENGINEERING

1. **General Aeronautics.** An introductory course giving briefly the essentials of aeronautics as applied to the airplane, airship, and other modern means of flight. Lectures and recitations. *Open to all students except freshmen.* Three hours credit. Each term.

2. **Theory of Aviation.** Presents a development of the underlying mechanics which form the basis for the study of modern aircraft. Lectures and recitations. *Must be preceded or accompanied by Math. 103 or 105 and 106 or 150.* Three hours credit. Each term.

3. **Theory and Design of Propellers.** Deals with the aerodynamic theories of the propeller and with its strength. The selection of propellers for specific conditions is discussed. Lectures and recitations. *Must be preceded by Eng. Mech. 2, and preceded or accompanied by Aero. Eng. 1.* Two hours credit. Each term.

4. **Basic Airplane Structures.** Includes the investigation of the design of the airplane from the structural standpoint. Lectures and recitations. *Must be preceded or accompanied by Aero. Eng. 1 and preceded by Civil Eng. 2.* Three hours credit. Each term.

5. **Airplane Design.** The design of an airplane from the aerodynamical and strength standpoints to meet certain specifications is discussed. Lectures and drawing. *Prerequisites: Aero. Eng. 2 and 4, accompanied by Aero. Eng. 23.* Two hours credit. Each term.

6. **Experimental Aerodynamics.** Modern methods for obtaining experimental aerodynamic data are discussed and illustrated. Lectures and laboratory. *Prerequisite: Aero. Eng. 2. Open only to seniors and graduates.* One hour credit. Each term.

11, 11a. **Dynamics of the Airplane.** An advanced study of the dynamics of the airplane and its parts. The mathematical theory of the stability of the airplane as a rigid body is given, and the subjects of spinning and the vibration and flutter of certain parts of the airplane are also discussed. Lectures and recitations. *Prerequisites: Aero. Eng. 2 and Math. 150. Aero. Eng. 11 is a prerequisite for 11a.* Two hours credit for each course.

12. **Seminar.** Reading and reports on selected aerodynamical and aeronautical problems. *Open only to graduates and seniors who receive special permission.* A reading knowledge of French and German is most desirable. Credit to be arranged. Each term.

13. **Advanced Design.** Continuation of Aero. Eng. 5, taking up some of the more complex or special problems. *Open primarily to graduates.* Credit to be arranged. Each term.

14. **Research.** Continuation of Aero. Eng. 6, offering an opportunity for students to pursue experimental investigations. *Prerequisite: Aero. Eng. 6.* Credit to be arranged. Each term.

15. **Theoretical Aerodynamics.** A summary of the fundamentals of the mathematical theory of hydrodynamics and its application to modern aerodynamics. The theory of the geometry and dynamics of airfoil sections is treated in considerable detail. *Prerequisites: Aero. Eng. 2 and Math. 150.* Three hours credit.

16. **Air Transportation.** Engineering and economic aspects. Two hours credit.

17. **Aircraft, Materials of Construction.** See Metal Proc. 110.

18. **Helicopters and Autogiros.** *Prerequisite: Aero. Eng. 2.* One hour credit.

19. **Analytical Research.** A theoretical investigation of problems in aeronautical engineering which are particularly suited to treatment by analytical and mathematical methods. Hours and credits to be arranged.

20. **Advanced Fluid Mechanics.** An advanced course in fluid mechanics dealing mainly with the physical aspects of various problems of fluid resistance, etc., and their application in aeronautical as well as other branches of engineering. *Prerequisites: Eng. Mech. 4 and Math. 150.* Three hours credit.

21. **Advanced Theory of Propellers.** The content of Aero. Eng. 3, omitting routine investigations, is covered in a short time and supplemented by a more critical investigation of the fundamental aerodynamic and strength theories of the propeller; special topics include windmills and blowers. Two hours credit.

22. **Propeller Research.** Investigation of special propeller and helicopter problems in the laboratory. Credit to be arranged.

23. **Airplane Structures.** Deals with the structural analysis of metal airplanes. Lectures cover the subject of stability of commonly used sections and shapes in aircraft structures under compression, bending, torsion, and combined stresses, and monocoque and semimonocoque structures. *Prerequisite: Aero. Eng. 4, or by special arrangement for students from other departments.* Three hours credit. Each term.

24. **Advanced Experimental Aerodynamics.** Covers the work presented in Aero. Eng. 6, but with considerably more attention to detail and a more elaborate discussion of the advanced theories and methods used in this field. Lectures and laboratory. *Prerequisites: Eng. Mech. 4 and Math. 150.* Two hours credit.

25. **Advanced Airplane Performance.** The relationship of engine, propeller, and airplane is considered in this course. The effect of changes in these items on the performance of the airplane as a whole are treated in detail. *Prerequisites: Aero. Eng. 2 and 3.* Two hours credit. Each term.

26. **Airplane Structures Laboratory.** The lectures and experiments include proof tests of control surfaces and control systems; stress distribution in a monocoque structure; the use of sensitive strain gages; drop tests of landing gears; and other special topics. *Prerequisites: Aero. Eng. 4 and 23.* One hour credit.

27. **Applied Aerodynamics.** Applies theoretical aerodynamics and modifications based on experiment to the calculation of actual air

loads on the airplane. *Prerequisites: Aero. Eng. 2 and Math. 150.* Three hours credit. Each term.

29. **Mechanics of Fluid Resistance.** The problems of resistance in fluid motion are treated in a broad way, consideration being given to viscous fluid resistance, wave resistance, and resistance due to fluid compressibility. *Prerequisite: Aero. Eng. 15.* Two hours credit.

30. **Advanced Airplane Structures.** Deals with the investigation and development of methods for the analysis of stressed-skin structures. Continuation of Aero. Eng. 23. *Prerequisite: Aero. Eng. 23.* Three hours credit.

53. ASTRONOMY

Professors RUFUS, and MCLAUGHLIN; Associate Professors ROSSITER* and MAXWELL; Assistant Professors LOSH and WILLIAMS.

The University Observatory is situated at the corner of Ann and Observatory Streets.

Its equipment includes a 37½-inch equatorial reflecting telescope, which is used for stellar spectrographic work; a 12½-inch equatorial refractor; a 6-inch meridian circle; a comet seeker; mean and sidereal clocks and chronometers, chronograph, theodolites, sextants, seismographs, computing machines, and measuring engines.

The Observatory Library contains about 6,000 volumes, devoted mainly to technical astronomy. It includes the more important works on theoretical and practical astronomy, many star catalogs, files of the leading astronomical periodicals, and the publications of the more important observatories.

The Astronomical Laboratory is located on the fifth floor and the roof of Angell Hall. The present equipment of this laboratory includes a 15-inch reflector, a 10-inch refractor, a 3-inch astronomical transit, a horizontal spectroheliscope, 3 portable refractors, a planetarium, celestial globes, and other smaller instruments.

The Observatory maintains, through the generosity of Mr. Robert P. Lamont, '91*e*, a branch observing station, called the Lamont-Hussey Observatory, in Bloemfontein, South Africa. The equipment includes a 27-inch refractor and a 6-inch visual and photographic telescope. The observers at Bloemfontein are devoting their time to research in the field of visual double stars.

Another branch observatory is the McMath-Hulbert Observatory, located at Lake Angelus, Michigan, of which Robert R. McMath, '14*e*, is Director. This institution specializes in the recording by the motion-picture method, of celestial phenomena showing motion or change. It contains a 10½-inch reflector, with much auxiliary apparatus, and a new solar tower, for studies of solar phenomena.

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* Professor Rossiter is in charge of the Lamont-Hussey Observatory of the University of Michigan, Bloemfontein, Orange Free State, South Africa.

CURRICULUM IN ASTRONOMY

Since this curriculum leads to fields other than engineering it is not listed for accrediting with the Engineers Council for Professional Development.

The first two years' work in any department of engineering constitutes good preparation for a curriculum looking toward the profession of astronomy.

Candidates for the degree of Bachelor of Science in Engineering (Astronomy) are required to complete the following program of studies:

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives	6
Math. 13, 14, 53, 54, 57, or 103	18
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2	2
Economics 53, 54	6
Total	65
b) *Secondary and Technical Courses*	
Eng. Mech. 1, 3	6
Civil Eng. 2	3
Surveying 1, 2	7
Surveying 5, or Astronomy 154	2
Astronomy 51, 53 (or 31, 32, 33), 101, 102, 151, 152, 156	20 or 22
Mathematics 105, 106, and 141, 142 or 145, 146	8 or 10
Physics 181, 186, 188, 195	8
Total	56 or 58
Summary:	
Preparatory Courses	65
Secondary and Technical Courses	56 or 58
Electives, nontechnical, additional 6 hours; in astronomy, physics, or other sciences, 11 or 13 hours	19 or 17
Total	140

COURSES IN ASTRONOMY

Astronomy 31, 32, 33, 103, and 104 are recommended to those who wish to obtain a general knowledge of modern astronomy without entering far into its mathematical details. Engineers are recommended to take Astronomy 51, with its accompanying laboratory

Astronomy 53, in place of 31, 32, and 33. Astronomy 35, 101, 102, 154, and 156 are recommended to those who wish to obtain a knowledge of practical astronomy in its applications to engineering and geodesy.

Courses in addition to those mentioned below are listed in the *Announcement* of the College of Literature, Science, and the Arts. These include advanced work in theoretical astronomy, practical astronomy, and astrophysics. The larger instruments of the Observatory are intended primarily for research and are available to that end to such students as have assigned problems requiring their use.

31. **Descriptive Astronomy. The Solar System.** Includes the fundamental principles of astronomy, and a presentation of the leading facts concerning the sun, moon, planets, and comets. Three lectures or recitations, and one observatory exercise. Three hours credit. Each term.

32. **Descriptive Astronomy, Stars and Nebulae.** Devoted mainly to stars and nebulae, including the study of the sun as a typical star. Three lectures or recitations, and one observatory exercise. Three hours credit. Each term.

33. **Observational Astronomy.** Constellation studies and telescopic examinations of the heavenly bodies. Selected problems with the celestial globe and equatorial telescope. Laboratory period of three hours. *Open to those who have had or are taking Astronomy 31, 32, or 35.* One hour credit. Fall and spring terms.

35. **Practical Astronomy.** The elements of spherical and geodetical astronomy, with practical applications. Theory of the determination of time, latitude, longitude, and azimuth. This course is intended primarily for students in engineering. Recitations and problems. *Open to those who have had trigonometry and analytical geometry.* Two hours credit. Spring term.

36. **Nautical Astronomy.** The celestial sphere and co-ordinate systems. Use of the sextant and nautical almanac. Designed to prepare students for a course in navigation. Two hours credit. Each term.

51. **General Astronomy.** Designed for students interested in the physical sciences. A treatment of methods of measurement and of the results of modern astrophysics *Prerequisites: high-school algebra and geometry, and Astronomy 31 or 32,* but the astronomy prerequisite is waived for students who have had high-school physics and trigonometry. Four hours credit. Fall term.

53. **Intermediate Laboratory Astronomy.** Experiments in the methods of observational astronomy, with emphasis on the principles and use of astronomical instruments. *Prerequisites: same as for Astronomy 51.* One hour credit. Fall term.

101. Practical Astronomy. Studies in spherical astronomy. Theory of the meridian circle and equatorial and their use in observational work. This course includes observational work with instruments and the reduction of measurements. Recitations, practical problems. *Open to those who have had trigonometry and analytical geometry.* Three hours credit. Fall term.

102. Navigation. The principles of pilotage, dead reckoning, and nautical astronomy. Lectures based on Bowditch's *American Practical Navigator,* supplemented by practical problems. *Open to those who have had plane trigonometry.* Three hours credit. Each term.

105. Variable Stars. Lectures, collateral reading, and observations of variables. *Prerequisites: Astronomy 31 and 32.* Three hours credit. Fall term.

151. Solar Physics. Studies of methods and results of modern solar research. Lectures and collateral reading. *Open to those who possess a general knowledge of astronomy and physics.* Two hours credit. Fall term.

152. Astrophysics. Studies of methods and results in physical astronomy and especially in stellar spectroscopy. Three recitations and one laboratory period each week. *Open to those who have had calculus and possess a general knowledge of astronomy and physics.* Four hours credit. Spring term.

154. Method of Least Squares. Theory of the error curve and of the combination of observational data according to the method of least squares. Recitations, problems. *Prerequisite: calculus.* Two hours credit. Spring term.

156. Advanced Practical Astronomy. Studies in continuation of Course 101. *Prerequisite: Astronomy 101 and calculus.* Three hours credit. Spring term.

54. CHEMICAL AND METALLURGICAL ENGINEERING

Professors G. G. BROWN, A. H. WHITE, A. E. WHITE, BRIER*, UPTHEGROVE, WOOD, and BAKER; Associate Professors THOMASSEN, McCREADY, PETTYJOHN*, SCHNEIDEWIND, and KATZ; Assistant Professors SIEBERT, FOUST*, and TOWNSEND; Dr. R. R. WHITE, Mr. BROWNELL, Mr. YORK, and Mr. JONES.

THE CHEMICAL ENGINEER

"Chemical engineering is that branch of engineering concerned with the development and application of manufacturing processes in which chemical or certain physical changes of materials are involved."* The chemical engineer is, therefore, essentially a process engineer and is concerned primarily with the design, construction, and operation of equipment and plants in which these processes take place.

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* On leave, active service, 1942-43.

It has been found that certain basic or unit operations such as heat transfer, evaporation, filtration, distillation, crushing, extracting, and drying are common to the processing of different materials and industries. Any manufacturing process with which the chemical engineer deals is made up of a sequence of such operations. His knowledge of these unit operations and their commercial application is one characteristic which distinguishes him from the chemist. Only by being thoroughly grounded in the principles of chemistry, physics, and mathematics and their application to industrial processes is it possible for the chemical engineer to make his proper contribution to the development and commercial production of the amazing multiplicity of new products from modern industry.

THE METALLURGICAL ENGINEER

Almost all that has been said of the chemical engineer applies to an equal degree to the metallurgical engineer, although the metallurgical engineer is more concerned with metals than with other engineering materials. The activities of the metallurgical engineer cover the extraction of metals from their ores, their melting, refining, alloying, casting, fabrication, and heat treatment, and their utilization in the various industries. He finds his work not only in the industries involved directly in the production of metals and metal products, but also to an ever-increasing extent in the industries utilizing, and dependent for their existence on, metals and metal products. Diminishing supplies of high-grade ores and an increasing demand for new alloys of superior qualities make this field one of ever-growing importance.

CURRICULA IN CHEMICAL AND METALLURGICAL ENGINEERING

The first four or five terms of undergraduate work are devoted largely to fundamental subjects or "tools" required for an understanding of the more specialized subjects. The last two terms include the courses in the special applications, or "use of the tools," to chemical and metallurgical problems, and offer opportunity for the better students to elect special research or design work in their chosen field.

GRADUATE TRAINING

The fact that chemical and metallurgical engineering involves application of chemistry in addition to mathematics and physics, which are the basis of other branches of engineering, indicates the importance of more than four years' study. This is definitely recognized by many of the larger corporations, who prefer a man with a master's or doctor's degree to one with a bachelor's degree on the grounds that the man with postgraduate training advances faster and further than an equally able man without such training. All students desiring to become candidates for a graduate degree must present substantially the equivalent of the undergraduate program required for the bachelor's degree in chemical or metallurgical engineering at the University of Michigan. Students whose undergraduate training has not been adequate will be required to make up the work which is lacking.

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* As defined by the American Institute of Chemical Engineers.

FACILITIES

The Chemical and Metallurgical Engineering Department is located in the East Engineering Building where it co-operates closely with the foundry and forge shop of the metal processing laboratories, the cement and asphalt work of the highway laboratories and the Department of Engineering Research.

The general Chemical and Metallurgical Engineering Laboratory occupies four floors in the north wing of the building and is well equipped for pilot plant work and studies of the unit operations and their integration into processes. All students in Chemical and Metallurgical Engineering are required to elect Course 29 in the General Laboratory. Equipment of the General Laboratory is also available for research work, as suggested in Course 110 *a, b, c, d* and *e*. A number of completely equipped special laboratories deal with the problems of particular industries or materials as suggested in Course 110, *f-x*. By making proper elections from among the advanced courses it is possible for the advanced student to obtain expert special instruction in a chosen field of specialization. Separate shops for mechanics', and students' use, the instructional laboratories as in metallography, melting and heat treating, pyrometry, physical measurements, gas and fuel, etc. can be merely mentioned here.

Visits of Inspection.—The educational value of visits of inspection is recognized, and inspection trips are made regularly in connection with the various courses. The great industrial development of the neighboring cities of Detroit and Toledo, as well as that of other points of Michigan within easy reach of Ann Arbor, allows a varied range of industries to be visited at small expense. The opportunities are so abundant that the list varies from year to year.

Summer Employment.—Each student is urged to obtain employment in a factory for at least one summer in order that he may acquire the viewpoint of the worker in an industrial organization. If he acquires professional knowledge, also, so much the better.

Student branches of the American Institute of Chemical Engineers, established in 1922, and the American Institute of Mining and Metallurgical Engineering, established in 1938, hold monthly meetings for discussion of topics of professional interest. Convenient and pleasant clubrooms are provided adjoining the seminar room in the East Engineering Building.

Military and Naval Science.—The College of Engineering contains units of the corps of engineers, infantry, signal corps, and ordnance in the Reserve Officers' Training Corps. Students completing the required work may obtain commissions as reserve officers. The ordnance unit is especially attractive to chemical and metallurgical engineers, and there is sufficient flexibility in the program so that they may obtain the necessary military or naval credits without increasing the time in residence, provided they take one summer in a military camp. See Sections 46 and 49.

CURRICULUM IN CHEMICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Chemical Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, a course from Group III, preferably Course 6	2
Nontechnical Electives	6
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E, 21E, 41	13
Drawing 1, 2, 3	8
Metal Proc. 2 and Ch.-Met. Eng. 1	5
Economics 153, 173	6
Total	74

b) *Secondary and Technical Courses*	
Chem. 67E, 169E, Organic Chemistry	8
Chem. 85E, 87E, Physical Chemistry	6
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Mech. Eng. 3, Heat Engines	4
Elec. Eng. 2*a*, Electric Apparatus and Circuits	4
Ch.-Met. Eng. 2, Engineering Calculations	3
Ch.-Met. Eng. 6, 13 and 15, Unit Operations	7
Ch.-Met. Eng. 11, Thermodynamics	3
Ch.-Met. Eng. 16, Laboratory Measurements	2
Ch.-Met. Eng. 17, Physical Metallurgy	3
Ch.-Met. Eng. 25, Chemical Industries	3
Ch.-Met. Eng. 29, Engineering Laboratory and Design	3
Ch.-Met. Eng. 34, Chemical Process Design	3
Total	56

Summary:	
Preparatory Courses	74
Secondary and Technical Courses	56
Electives	10
Total	140

Students in chemical engineering who are also candidates for a degree in mathematics are permitted to make the following substitutions:

1. In the mathematics curriculum substitute three hours of chemistry (beyond 5E) for Eng. Mech. 3.

2. In the chemical curriculum substitute three hours of advanced mathematics for Economics 173.

PROGRAM IN CHEMICAL ENGINEERING OF NINE OR EIGHT TERMS

Students who earn an average grade of B, 3.0 points, on the first term program may complete the entire program in eight terms rather than in nine terms by carrying an average of about 18 hours per term. See Rules Governing Election of Studies, section 19*a*. This may be done by advancing the courses marked x to the preceding term.

FIRST TERM

COURSES	HOURS
Math. 13	4
*English 1	3
*English 2	1
Drawing 1	3
†Chem. 5E or Ch.-Met. 1 and Metal Proc. 2	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

SECOND TERM

COURSES	HOURS
Math. 14	4
*English 3	2
*English (Group II)	2
Drawing 2	3
†Ch.-Met. 1 and Metal Proc. 2 or xChem. 5E	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

THIRD TERM

Math. 53	4
Physics 45	5
xChem. 21E	4
Drawing 3 or Eng. Mech. 1	2 or 3
	15 or 16

FOURTH TERM

Math. 54	4
Physics 46	5
xEng. Mech. 1 or xDrawing 3	3 or 2
xChem. 41	4
	16 or 15

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

FIFTH TERM

xChem. 67E	3
xCh.-Met. 2	3
Eng. Mech. 2	4
xMech. Eng. 3	4
Electives	2
	16

SIXTH TERM

xChem. 85E	3
xChem. 169E	5
xCh.-Met. 11	3
xCh.-Met. 6	2
Electives	3
	16

SEVENTH TERM

xChem. 87E	3
xCh.-Met. 13	2
xCh.-Met. 16	2
xCh.-Met. 25	3
xElec. Eng. 2*a*	4
Electives	2
	16

EIGHTH TERM

xEconomics 153	3
xCh.-Met. 15	3
xCh.-Met. 17	3
xCh.-Met. 29	3
xEnglish III	2
Electives	2
	16

NINTH TERM

xEconomics 173	3
xCh.-Met. 34	3
xElectives	7 or 5
	13 or 11

CURRICULUM IN METALLURGICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Metallurgical Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, a course from Group III, preferably Course 6	2
Nontechnical Electives	6
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E, 21E, 41	13
Drawing 1, 2, 3	8
Metal Proc. 2, and Ch.-Met. Eng. 1	5
Economics 153 and 54 or 173	6
Total	74

Secondary and Technical Courses for Metallurgical Engineers

Chem. 53, Organic Chemistry	4
Chem. 85E, 87E, Physical Chemistry	6
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Mech. Eng. 3, Heat Engines	4
Elec. Eng. 2*a*, Electrical Apparatus and Circuits	4
Metal Proc. 9, Foundry	2
Mineralogy 99, Crystallography	1
Ch.-Met. Eng. 2, Eng. Calculations	3
Ch.-Met. Eng 6 and 13, Unit Operations	4
Ch.-Met. Eng. 11, Thermodynamics	3
Ch.-Met. Eng. 16, Laboratory Measurements	2
Ch.-Met. Eng. 19, Metallurgical Process Design	4
Ch.-Met. Eng. 27 and 28, Physical Metallurgy	7
Ch.-Met. Eng. 29, Engineering Laboratory and Design	3
Ch.-Met. Eng. 44, X-rays	3
Total	57

Summary:

Preparatory Courses	74
Secondary and Technical Courses	57
Electives	9
Total	140

Students in metallurgical engineering who are also candidates for a degree in mathematics are permitted to make the following substitutions:

1. In the mathematics curriculum substitute three hours of chemistry (beyond 5E) for Eng. Mech. 3.

2. In the metallurgical curriculum substitute three hours of advanced mathematics for Economics 173.

PROGRAM IN METALLURGICAL ENGINEERING OF NINE OR EIGHT TERMS

Students who earn an average grade of B, 3.0 points, on the first term program may complete the entire program in eight terms rather than in nine terms by carrying an average of about 18 hours per term. See Rules Governing Election of Studies, section 19*a*. This may be done by advancing the courses marked x to the preceding term.

FIRST TERM

COURSES	HOURS
Math. 13	4
*English 1	3
*English 2	1
Drawing 1	3
†Chem. 5E or Ch.-Met. 1 and Metal Proc. 2	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

SECOND TERM

COURSES	HOURS
Math. 14	4
*English 3	2
*English (Group II)	2
Drawing 2	3
†Ch.-Met. 1 and Metal Proc. 2 or xChem. 5E	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

THIRD TERM

Math. 53	4
Physics 45	5
xChem. 21E	4
Drawing 3 or Eng. Mech. 1	2 or 3
	15 or 16

FOURTH TERM

Math. 54	4
Physics 46	5
xEng. Mech. 1 or xDrawing 3	3 or 2
xChem. 41	4
	16 or 15

FIFTH TERM

xChem. 53	4
xCh.-Met. 2	3
xMech. Eng. 3	4
Metal Proc. 9	2
Mineralogy 99	1
Electives	2
	16

SIXTH TERM

xChem. 85E	3
xCh.-Met. 11	3
xCh.-Met. 16	2
xCh.-Met. 6	2
Eng. Mech. 2	4
Electives	2
	16

SEVENTH TERM

xChem. 87E	3
Econ. 153	3
xCh.-Met. 13	2
xCh.-Met. 27	4
xElec. Eng. 2*a*	4
	16

EIGHTH TERM

Economics 173	3
xCh.-Met. 28	3
xCh.-Met. 19	4
xCh.-Met. 29	3
xEnglish III	2
	15

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

NINTH TERM

xCh.-Met. 44	3
xElectives	11 or 9
	14 or 12

ELECTIVES

The undergraduate curricula in chemical and metallurgical engineering are designed to train the student in the basic principles involved in processing materials. A student so trained is prepared to enter almost any industry. The application of these basic principles to specific industries is covered in many of the advanced courses, which may be elected by the student who has particular interest in a special field. These courses may be included among the electives of the undergraduate program, taken as additional work, or included in a postgraduate program for an advanced degree. The usual procedure for an undergraduate is to elect the appropriate subdivision of Chemical-Metallurgical Engineering 110 to which may be added as many cognate courses as time permits. For example, the student may prepare himself as thoroughly as he may wish for work in the field of petroleum and natural gas by elections from the following courses: Ch.-Met. Eng. 55, 110*f*, 155, 254, 255, Geol. 145, Chem. 291, 292, and others. The members of the staff are always available for consultation in regard to the selection of elective courses.

Students working for the two degrees—Bachelor of Science in Engineering (Chemical Engineering) and Bachelor of Science in Engineering (Metallurgical Engineering)—will follow the same preparatory courses which are common to both chemical and metallurgical curricula, and will follow the list given below for the secondary and technical courses. Notice that 152 hours of credit are required for these two degrees.

b) *Secondary and Technical Courses for the two degrees, Bachelor of Science in Engineering (Chemical Engineering) and Bachelor of Science in Engineering (Metallurgical Engineering).*

	Hours
Chem. 67E, 169E, Organic Chemistry	8
Chem. 85E, 87E, Physical Chemistry	6
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Mech. Eng. 3, Heat Engines	4
Elec. Eng. 2*a*, Electrical Apparatus and Circuits	4
Met. Proc. 9, Foundry	2
Mineralogy 99, Crystallography	1
Ch.-Met. Eng. 2, Engineering Calculations	3
Ch.-Met. Eng. 6, 13, 15, Unit Operations	7
Ch.-Met. Eng. 11, Thermodynamics	3
Ch.-Met. Eng. 16, Laboratory Measurements	2
Ch.-Met. Eng. 19, Metallurgical Process Design	4

Ch.-Met. Eng. 25, Chemical Industries	3
Ch.-Met. Eng. 27, 28, Physical Metallurgy	7
Ch.-Met. Eng. 29, Engineering Laboratory and Design	3
Ch.-Met. Eng. 34, Chemical Process Design	3
Ch.-Met. Eng. 44, X-Rays	3
Total	70

Summary for the two degrees:

Preparatory Courses	74
Secondary and Technical Courses	70
Electives	8
Total	152

THE CURRICULA IN CHEMICAL AND INDUSTRIAL ENGINEERING AND IN METALLURGICAL AND INDUSTRIAL ENGINEERING

Eleven-term curricula in chemical or metallurgical engineering and business administration lead to the degree of Bachelor of Science in Engineering (Chemical Engineering or Metallurgical Engineering) at the completion of 141 hours, and to the degree of Master of Science (Industrial Engineering) at the completion of two additional terms. The undergraduate programs contain the full program in chemical engineering or in metallurgical engineering with the substitution of Economics 53, 54, 71, and 72 and Business Administration 113 for the economics and electives specified in the usual course. Students will then enroll in the Graduate School and at the completion of two terms' work on an approved program will receive the Master of Science degree in Industrial Engineering.

COURSES IN CHEMICAL AND METALLURGICAL ENGINEERING

1. **Engineering Materials.** Metals, alloys, cement, clay products, protective coatings, fuels, and water. An introductory course. Two lectures, two recitations. Required for all engineering students. *Prerequisite: an acceptable high-school course in chemistry or Chem.* 3, *and preceded or accompanied by Metal Proc. 2.* Three hours credit. Each term.

2. **Engineering Calculations.** Material and energy balances and their application to fuels, furnaces, drying, combustion, and other chemical and metallurgical problems. Two lectures and two recitations. *Prerequisites: Ch.-Met. Eng. 1 and Physics 45.* Three hours credit.

6. **Solids Handling and Separation Operations.** Equipment and theory as applied to crushing, grinding, size separation, sedimentation, extraction, and filtration. Two lectures and one recitation. *Prerequisite: Ch.-Met. Eng. 2.* Two hours credit.

7. **Metals and Alloys.** Structures and properties as affected by composition, mechanical and thermal treatment, with special em-

phasis on the utilization of common metals and alloys and their behavior in service. Two lectures, one recitation. May not be elected by chemical or metallurgical engineers. *Prerequisite: Ch.-Met. Eng. 1.* Two hours credit.

10. **Fuels.** Laboratory testing of fuels, gases, oils and water, and interpretation of results. Is scheduled with Met. Eng. 7. One hour credit.

11. **Thermodynamics.** The laws of energy applied to continuous or flow processes, chemical equilibria, properties of materials and solutions, and the concept of availability. Two lectures and two recitations. *Prerequisites: Ch.-Met. Eng. 2 and Math. 54.* Three hours credit.

13. **Fluid Flow and Heat Transfer Calculations.** Equipment and theory of these unit operations and their application in chemical and metallurgical operations. One lecture and two recitations. *Must be preceded or accompanied by Ch.-Met. Eng. 11.* Two hours credit.

15. **Unit Operations Design.** Calculations are made for the design of gas absorption, distillation, drying and crystallization operations. Two lectures, two recitations. *Prerequisites: Ch.-Met. Eng.* 13, *and preceded or accompanied by Chem.* 87*E.* Three hours credit.

16. **Laboratory Measurements.** Physical-chemical measurements and determination of properties. Options are provided to meet the major interests of the student. Two laboratory periods of four hours each. *Must be preceded or accompanied by Chem. 85E.* Two hours credit.

17. **Physical Metallurgy.** The structures of metals as affected by composition and thermal and mechanical treatment; their resultant physical properties and behavior in service. One lecture, two recitations and one laboratory period. *Prerequisite: Ch.-Met. Eng. 16.* Three hours credit.

19. **Metallurgical Process Design.** The application of principles involved in the extraction of metals from ores, the production of alloys and their commercial shapes or forms to process design. Three lectures and two recitations. *Prerequisites: Ch.-Met. Eng. 6 and 13.* Four hours credit.

20. **Plant Work.** Credit is given for a satisfactory report on some phase of work done in a plant. The nature of the problem and registration must be approved before entering upon the work. One hour credit.

21. **Chemical Plant Design Problem.** The American Institute of Chemical Engineers holds an annual competition for the solution

of a problem open to all undergraduate students. One hour. A credit of one hour will be granted to any student who submits a solution of this problem which is satisfactory to the staff of the Department.

25. **Chemical Industries.** Principles and processes involved in numerous chemical industries. Three lectures and one recitation. *Must be preceded or accompanied by Chem. 169E.* Three hours credit.

27. **Physical Metallurgy I.** Structures and properties of metals, as related to composition and thermal and mechanical treatment. One lecture, two recitations and two three-hour laboratory periods. *Prerequisite: Ch.-Met. Eng. 16.* Four hours credit.

28. **Physical Metallurgy II.** Thermal and mechanical properties of metals as related to macro- and microstructure. Two lectures, one recitation, and one laboratory period. *Prerequisite: Ch.-Met. Eng. 27.* Three hours credit.

29. **Engineering Laboratory and Design.** Laboratory determination of actual operating data of equipment and the application of these data in design of plant. Experiments, reports, and problems. Divided into two principal options, (1) Chemical Engineering; (2) Metallurgical Engineering. Lectures, recitations, and laboratory. *Prerequisite: Ch.-Met. Eng. 15 or 19.* Three hours credit.

34. **Chemical Process Design.** Application of chemistry and the unit operations to the design of chemical processes particularly in the field of heavy chemicals. Two lectures and two recitations. *Must be preceded or accompanied by Ch.-Met. Eng. 15.* Three hours credit.

44. **X-Ray Studies of Engineering Materials.** The principal methods. Two lectures, one recitation, and one three-hour laboratory period. *Prerequisites: Ch.-Met. Eng.* 17 *or 27 and Mineralogy* 99. Three hours credit.

55. **Petroleum Laboratory.** Determination of properties of fuels, oils, gases, and special methods used in the petroleum industry. *Must be preceded by Ch.-Met. Eng. 16.* One or two hours credit.

102. **Heat and Material Balances.** Application of method of heat and material balances to chemical and manufacturing processes. *Prerequisite: Ch.-Met. Eng. 34.* Two recitations. Two hours credit.

105. **Chemical Engineering Thermodynamics.** A study of the principles of the three fundamental laws of energy as applied to chemical and metallurgical engineering problems. Two lectures and two recitations. *Prerequisites: Ch.-Met. Eng. 2, 11, calculus, and physical chemistry.* Three hours credit.

109. **Research Seminar.** Discussion of research of staff and graduate students. Required of all applicants and candidates for the doctorate; no credit.

110. **Special Research and Design Problems.** Laboratory and conferences. Hours and credit to be arranged.
a) Heat transfer and evaporation.
b) Distillation and gas absorption.
c) Extraction and leaching.
d) Filtration and sedimentation.
e) Transportation and handling of fluids.
f) Petroleum, natural gas, and motor fuels.
g) Gas manufacture, properties and uses of coal gas, water gas, oil gas, and producer gas.
h) Hydraulic cements as influenced by chemical composition and temperature of burning.
i) Electrodeposition and electrochemical processes.
j) Paint, varnish, and pyroxylin lacquers.
k) Pulp and paper manufacture.
l) Plastics.
m) Ferrous metallurgy. Structures and properties of non-ferrous metals.
o) High-temperature metallurgical problems.
x) Application of x-rays to the structure and properties of materials.

113. **Fluid Flow, Heat Flow, and Evaporation.** The fundamental theory of these processes and of the equipment for their operation. Lectures and recitation. *Prerequisite: Ch.-Met. Eng. 15.* Two hours credit.

114. **Crushing, Classification, Filtration, Calcination, and Conveying.** The fundamental theory of these processes and of the equipment for their operation. Lectures and recitations. *Prerequisites: Ch.-Met. Eng. 15 and 17.* Two hours credit.

115. **Drying, Distillation, Extraction, and Gas Absorption.** The fundamental theory of these processes and of the equipment for their operation. Lectures and recitations. *Prerequisite: Ch.-Met. Eng. 15.* Two hours credit.

121. **Design of Chemical Engineering Equipment.** The student selects some piece of chemical machinery and makes a complete set of drawings that would be required for its actual construction. Conferences and drafting. *Prerequisites: Ch.-Met. Eng. 15 and 29.* Three hours credit.

125. **Seminar in High Molecular Weight Polymers.** *Prerequisite: Ch.-Met. Eng. 25.* One to two hours credit.

141. **Metallurgy of Iron and Steel.** A critical study of the making of steel. Two lectures and one recitation. *Prerequisites: Ch.-Met. Eng. 6 and 19.* Two hours credit.

143. Metallography of the Nonferrous Metals. The microscopic structure of the common nonferrous metals and alloys, and of the effect on their structure and properties of heat treatment, mechanical work, and composition. One lecture and one laboratory period. *Prerequisites: Ch.-Met. Eng. 28 and a course in physical chemistry.* Two hours credit.

144. X-Ray Studies of Engineering Materials. Lectures and assigned work. *Prerequisites: Ch.-Met. Eng. 44, mathematics and physics.* Three hours credit.

149. Physical Metallurgy of Cast Ferrous Metals. A study of the theory and the mechanism underlying the solidification, structures, and properties of cast ferrous metals. Lectures and recitation. *Prerequisite: Ch.-Met. Eng. 28.* Two hours credit.

150. Physical Metallurgy of Wrought Ferrous Metals. A study of the theory of alloy additions to steel, and effect of alloying elements on the physical properties of steel. Two lectures, one recitation, and one laboratory demonstration. *Prerequisite: Ch.-Met. Eng. 28.* Two hours credit.

151. Furnace Design and Construction. The study and application of the principles of furnace design, furnace atmospheres and refractory materials used in furnace construction. Two lectures and one recitation. *Prerequisite: Ch.-Met. Eng. 13.* Two hours credit.

152. Pyrometry and Furnace Control. The theory, construction, calibration, and use of commercial pyrometers; the methods of thermal analysis, and the various means of temperature control in furnaces. One recitation and one laboratory period. *Prerequisite: Ch.-Met. Eng. 16.* Two hours credit.

155. Petroleum Refining. The process and design of engineering equipment used in the manufacture of petroleum products and natural gasoline. Lectures and recitations. *Prerequisite: Ch.-Met. Eng. 15.* Three hours credit.

171. Explosives. The process used in the manufacture of commercial and military explosives and pyrotechnic materials; their properties and uses. Lectures and recitations. *Prerequisite: Ch.-Met. Eng. 25* Three hours credit.

172. Pulp and Paper. The processes used in the manufacture of pulp and paper; their properties and uses. Lectures and recitations. *Prerequisite: Ch.-Met. Eng. 13.* Two hours credit.

205. Applied Thermodynamics. An advanced analytical study of chemical engineering processes from the standpoint of quantitative thermodynamics and physical chemistry. A continuation of Ch.-Met. 105. Lectures and recitations. Two hours credit.

215. Design of Chemical Plants, on the basis of economic balances. *Prerequisites: Ch.-Met. Eng. 113, 114 and 115, and a course in machine design.* Three hours credit.

221. Plant Location and Layout, and the design and selection of processes and auxiliary equipment. *Prerequisites: Ch.-Met. Eng. 113, 115 and 121.* Three hours credit.

241. Physical Metallurgy. An advanced study of the theory and principles fundamental to the mechanical and thermal treatment of metals and alloys. *Prerequisites: Ch.-Met. Eng. 19, 105 and 143.* Two hours credit.

244. Constitution of Metals and Alloys. An advanced study of metallic structure based on properties of single crystals and aggregates. *Prerequisite: Ch.-Met. Eng. 144.* Two hours credit.

245. Thermodynamics Applied to Metallurgical Problems. An analytical study of metallurgical problems from the standpoint of quantitative thermodynamics and physical chemistry. Lectures and recitations. *Prerequisite: Ch.-Met. Eng. 105 and 143.* Two hours credit.

254. Petroleum-Production Engineering. The application of chemical engineering to gases and liquids under high pressure as encountered in the production of natural gases and crude oil, and in the estimation of reserves. *Prerequisite: Ch.-Met. Eng. 155.* Three hours credit.

255. Petroleum-Refining Engineering. The application of chemical engineering to the design of petroleum refineries. *Prerequisite: Ch.-Met. Eng. 155.* Two hours credit.

55. CIVIL ENGINEERING

Professors GRAM, HOAD, DECKER, WORLEY, CISSEL, MORRISON, WISLER, SHERLOCK, BOUCHARD, and SADLER; Associate Professors CAREY, EMMONS, and HOUSEL; Assistant Professors ALT, MCFARLAN, YOUNG, MAUGH, BLEEKMAN, and BRATER; Mr. DAVIES and Mr. BOYD.

The Department of Civil Engineering is organized into the several administrative divisions described below, corresponding to the specialized practice in which civil engineers are engaged. Each of these divisions under the direction of an experienced engineer and teacher contributes to the program of courses required of all students, but there is opportunity for only a few advanced courses in any division within the limits of the four year schedule.

Geodesy and Surveying have to do with the making, recording, and reduction of observations for determining the relative positions of points on or near the earth's surface. Geodetic theory is applied when the work is of such extent as to be influenced by the size and shape of the earth. The practice of plane surveying is confined to relatively small areas, is essential for determining land boundaries, for the planning of construction, for directing construction according to design, and for the making of maps and systematic records for general purposes.

Structural Engineering deals with the theory, design, and construction of structures, such as bridges, buildings, dams, retaining walls, etc., involving the use of steel, reinforced concrete, and timber.

Hydraulic Engineering takes up the control and use of water, including irrigation, drainage, water power, and navigable rivers and harbors, and deals with the measurement of water and the design and construction of dams, locks, wharves, irrigation works, and all other forms of hydraulic structures.

Transportation Engineering deals with railroads, highways, waterways, and other forms of transportation; location, design and construction, maintenance, operation, and also the history and economics of transportation systems.

Sanitary Engineering has to do with the planning, construction, and operation of waterworks, sewerage and drainage systems, water-purification plants, and works for the treatment and disposal of city sewage and industrial wastes; with the improvement and regulation of natural waters for purposes of sanitation; with air sanitation; and with the principles and standards for the ventilation of buildings and for working under compressed air.

Municipal Engineering deals with the design, construction, maintenance, and management of the streets, pavements, sewers, systems of transportation, utilities, and other public improvements which, taken together, constitute the physical structure of the modern city, with comprehensive planning for cities and metropolitan areas, with the management of public utilities, and in general with the creation and maintenance of safe and wholesome physical conditions within the city.

Public Health Engineering has to do more particularly with governmental supervision and control of all those activities of an engineering nature which are definitely related to public health. An effort has been made to arrange the details of the course of training so that graduates will be prepared not only for civil engineering practice but also for an active interest in social and public service.

Major Electives.—As early as practicable the student should select that division of civil engineering in which he may have a major interest, and confer with the professor in charge of the division relative to the completion of his program.

Graduate Work leading to advanced degrees is offered to graduates whose records indicate that they can pursue it profitably. Conditions under which such work may be undertaken are described in the *Announcement* of the Horace H. Rackham School of Graduate Studies of the University.

Fellowships of interest to students in civil engineering are described in section 28.

The Transportation Library offers unusual opportunities for research. It contains many rare books and pamphlets relating to the origin, history, and development of the various transportation systems as well as complete files of current magazines and reports.

Highway Laboratories.—Through a co-operative arrangement between the University and the State Highway Department, the testing of materials for use in state highways and bridges is done at the University. The work of the state is, in general, done in the rooms used for student work, so that students secure the benefits to be derived from observing the work of trained state employees.

Camp Davis.—The University of Michigan was the pioneer in the establishment and maintenance of a camp for field work in surveying. The camp was organized under the supervision of the late Professor J. B. Davis in 1874. Several sites were occupied in Michigan until 1929, when the University purchased lands in Jackson's Hole, Wyoming, for the location of the present camp.

Camp Davis is located in the valley of the Hoback River twenty miles southeast of the town of Jackson, Wyoming, and seventy-five miles south of Yellowstone National Park. The elevation of the camp, over 6,000 feet above sea level, the nature of the surrounding area, and the climate combine to make this location very nearly ideal for a summer surveying camp.

A summary of the necessary preparatory training, with an outline of the work covered at the camp, and other information, is contained in a special circular which may be obtained upon application to the Camp Director, Professor Harry Bouchard, 209 West Engineering Building.

Advice to Students of other colleges and universities, with regard to planning their courses before coming to the University is given in section 7.

Military and Naval Science.—The attention of prospective students in civil engineering is called to the Reserve Officers' Training Corps. Those who consider taking military or naval science are urged to enroll at the beginning of their course. For further details see sections 46 and 49.

CURRICULUM IN CIVIL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Civil Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English 6	2
Nontechnical Electives	6
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2	6
Geology 11	4
Ch.-Met. Eng. 1 and Metal Proc. 2	5
Economics 53, 54	6
Total	68

b) *Secondary and Technical Courses*	
Surveying 1, 2	7
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Eng. Mech. 2*a*, Laboratory in Strength of Materials	1
Eng. Mech. 3, Dynamics	3
Eng. Mech. 4, Fluid Mechanics	3
Elec. Eng. 2*a*, Electrical Apparatus and Circuits	4
Mech. Eng. 3, Heat Engines	4
Civil Eng. 1, Structural Drafting	2
Civil Eng. 2*c*, Theory of Structures	3
Civil Eng. 3, Reinforced Concrete	3
Civil Eng. 5*a*, Elementary Design of Structures	3
Civil Eng. 10, Hydrology	3
Civil Eng. 12, Water Power Engineering	2
Civil Eng. 26, Specifications and Contracts	2
Civil Eng. 30, Water Works	3
Civil Eng. 32, Sewerage and Drainage	2
Civil Eng. 40, Highway Engineering	2
Civil Eng. 42*c*, Concrete Mixtures	1
Civil Eng. 50, Railroad Engineering	2
Total	57

c) *Electives*	*Hours*
Major and Free	15

Summary:

Preparatory Courses	68
Secondary and Technical Courses	57
Electives	15
Total	140

Electives

a) *Major Electives:*

One of the following groups, each including a design course, must be selected as a major. Substitution for any other than the design course is subject to the approval of the Chairman of the Civil Engineering Department.

Geodesy and Surveying

Surv. 3, Summer camp in Surveying	8
Choice of any—	
Civil Eng. Design and accompanying Theory Courses	5

Structural Engineering

Civil Eng. 5*b*, Design of Structures	3
Civil Eng. 4, Advanced Theory of Structures	2
Choice of either—	
Civil Eng. 6, Applied Soil Mechanics	3
Civil Eng. 7*h*, Rigid Frame Structures	3

Hydraulic Engineering

Civil Eng. 16, Hydraulic Engineering Design	3
Civil Eng. 11, Hydraulics	2
Civil Eng. 14, Hydraulic Structures	3

Municipal and Sanitary Engineering

Civil Eng. 35, Sanitary Engineering Design	3
Civil Eng. 31, Water Purification	2
Civil Eng. 33, Sewage Disposal	3
Civil Eng. 34, Municipal and Industrial Sanitation	3

Transportation Engineering (Highway)

Civil Eng. 54, Railway and Highway Location Design	3
Civil Eng. 41, Advanced Highway Engineering	2
Civil Eng. 45, Highway Traffic Control	2

Transportation Engineering (Railroad)

Civil Eng. 54, Railway and Highway Location Design	3
Civil Eng. 51, Economics of Railroad Construction and Operation	2
Civil Eng. 52, Railroad Maintenance	2

b) *Free Electives*

The remaining elective hours may be filled by courses offered by any department in the University, subject to the approval of the Chairman of the Civil Engineering Department.

Note.—Students completing military or naval science (advanced group) as part of their elective requirements will be required to elect not less than five hours from one of the above groups, and such elections shall include a design course.

PROGRAM

FIRST TERM		SECOND TERM	
COURSES	HOURS	COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4	Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 1	3	*English 3	2
*English 2	1	*English (Group II)	2
Drawing 1	3	Drawing 2	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5	†Ch.-Met. Eng. 1 and Metal Proc. 2 or Chem. 5E	5
Assembly	0	Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1	‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17		16 or 17

Note.—See section 35 for ruling on freshmen repeating subjects graded D.

THIRD TERM		FOURTH TERM	
Math. 53	4	Math. 54	4
Physics 45	5	Eng. Mech. 2	4
Surveying 1	3	Eng. Mech. 2*a*	1
Eng. Mech. 1	3	Surveying 2	4
Civil Eng. 1	2	Civil Eng. 40	2
		Elective	2
	17		17

Summer Session (at Camp Davis)

Electives 8

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

FIFTH TERM		SIXTH TERM	
COURSES	HOURS	COURSES	HOURS
Electives	2	Civil Eng. 5*a*	3
Physics 46	5	Civil Eng. 3	3
Civil Eng. 2*c*	3	Economics 54	3
Economics 53	3	Eng. Mech. 3	3
Civil Eng. 42*c*	1	Civil Eng. 30	3
Eng. Mech. 4	3	Civil Eng. 50	2
	17		17

SEVENTH TERM		EIGHTH TERM	
Geology 11	4	English 6	2
Civil Eng. 12	2	Mech. Eng. 3	4
Civil Eng. 10	3	Elec. Eng. 2*a*	4
Civil Eng. 32	2	Civil Eng. 26	2
Electives	5	Electives	4
	16		16

CURRICULUM IN TRANSPORTATION AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Transportation Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English 6	2
Nontechnical Electives	6
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2	6
Ch.-Met. Eng. 1 and Metal Proc. 2	5
Economics 53, 54, 173	9
Total	67

b) *Secondary and Technical Courses*	
Surveying 1	3
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Eng. Mech. 2*a*, Laboratory on Strength of Materials	1
Eng. Mech. 3, Dynamics	3
Civil Eng. 1, Structural Drafting	2
Civil Eng. 2*c*, Theory of Structures	3
Civil Eng. 3, Reinforced Concrete	3
Civil Eng. 5*a*, Elementary Design of Structures	3
Civil Eng. 26, Specifications and Contracts	2

	Hours
Civil Eng. 27, Public Utility Problems	2
Civil Eng. 40, Highway Engineering	2
Civil Eng. 42*c*, Concrete Mixtures	1
Civil Eng. 50, Railroad Engineering	2
Civil Eng. 53, Terminal Design	3
Civil Eng. 58, Transportation	2
Mech. Eng. 3, Heat Engines	4
Elec. Eng. 2*a*, Electrical Apparatus and Circuits	4
Total	47

c) *Group Options—one of the four groups listed below*

Railroad	*Hours*
Civil Eng. 46	3
Civil Eng. 52*a*	2
Civil Eng. 54	3
Elec. Eng. 8	2
Electives	16
	26

Highway	*Hours*
Civil Eng. 6	3
Civil Eng. 42*a*	2
Civil Eng. 44	2
Civil Eng. 45	2
Civil Eng. 46	3
Mech. Eng. 29	3
Electives	11
	26

Traffic	
Civil Eng. 44	2
Civil Eng. 45	2
Civil Eng. 47	2
Mech. Eng. 29	3
Land. Arch. 102	2
Electives	15
	26

Marine	
Naval Arch. 2	3
Naval Arch. 4	3
Naval Arch. 5	4
Mar. Eng. 9	3
Electives	13
	26

Aeronautical	
Aero. Eng. 1	3
Aero. Eng. 3	2
Aero. Eng. 4	3
Math. 103	3
Electives	15
	26

Automotive	
Mech. Eng. 2	3
Mech. Eng. 6	4
Mech. Eng. 29	3
Mech. Eng. 32	3
Electives	13
	26

Summary:

Preparatory Courses	67
Secondary and Technical Courses	47
Group Options	26
Total	140

PROGRAM

FIRST TERM

COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4
*English 1	3
*English 2	1
Drawing 1	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

SECOND TERM

COURSES	HOURS
Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 3	2
*English (Group II)	2
Drawing 2	3
†Ch.-Met. Eng. 1 and Metal Proc. 2 or Chem. 5E	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

THIRD TERM

COURSES	HOURS
Math. 53	4
Physics 45	5
Surveying 1	3
Economics 53	3
Civil Eng. 1	2
	17

FOURTH TERM

COURSES	HOURS
Math. 54	4
Physics 46	5
Eng. Mech. 1	3
Economics 54	3
Civil Eng. 40 (Aero. & Marine)	2
or	
Electives (Rwy. & Hwy.)	2
	17

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

Railroad	*Hours*	*Hi-way*	*Hours*	*Aero.*	*Hours*	*Marine*	*Hours*
FIFTH TERM							
E.M. 2	4	E.M. 2	4	E.M. 2	4	E.M. 2	4
E.M. 2*a*	1	E.M. 2*a*	1	E.M. 2*a*	1	E.M. 2*a*	1
Ec. 173	3	Ec. 173	3	Ec. 173	3	Ec. 173	3
C.E. 50	2	C.E. 50	2	C.E. 50	2	C.E. 50	2
C.E. 2*c*	3	C.E. 2*c*	3	C.E. 2*c*	3	C.E. 2*c*	3
Nontech. Electives	3	Nontech. Electives	3	Aero. 1	3	N.A. 2	3
	16		16		16		16
SIXTH TERM							
C.E. 5*a*	3	C.E. 5*a*	3	C.E. 5*a*	3	C.E. 5*a*	3
C.E. 40	2	C.E. 40	2	Math. 103	3	E.M. 3	3
E.M. 3	3	E.M. 3	3	E.M. 3	3	C.E. 26	2
C.E. 26	2	C.E. 26	2	C.E. 26	2	C.E. 58	2
C.E. 58	2	C.E. 58	2	C.E. 58	2	N.A. 4	3
Electives	4	C.E. 42*a*	2	Aero. 3	2	Electives	4
		Electives	2	Electives	2		
	16		16		17		17
SEVENTH TERM							
C.E. 3	3	C.E. 3	3	C.E. 3	3	C.E. 3	3
C.E. 53	3	C.E. 53	3	C.E. 53	3	C.E. 53	3
C.E. 27	2	C.E. 27	2	C.E. 27	2	C.E. 27	2
C.E. 52*a*	2	C.E. 6	3	Aero. 4	3	N.A. 5	4
E.E. 8	2	C.E. 44	2	Engl. 6	2	Engl. 6	2
Electives	5	Electives	4	Electives	4	Electives	3
	17		17		17		17
EIGHTH TERM							
E.E. 2*a*	4	E.E. 2*a*	4	E.E. 2*a*	4	E.E. 2*a*	4
Engl. 6	2	Engl. 6	2	C.E. 57	3	Mar.E. 9	3
C.E. 46	3	C.E. 46	3	Nontech. Electives	3	C.E. 57	3
C.E. 54	3	C.E. 45	2	Electives	9	Nontech. Electives	3
Electives	5	M.E. 29	3			Electives	6
		Electives	3				
	17		17		16		16
NINTH TERM							
M.E. 3	4	M.E. 3	4	M.E. 3	4	M.E. 3	4
C.E. 42*c*	1	C.E. 42*c*	1	C.E. 42*c*	1	C.E. 42*c*	1
Nontech. Electives	3	Nontech. Electives	3	Nontech. Electives	3	Nontech. Electives	3
	8		8		8		8

NOTE.—For students electing the Automotive Group Option or Traffic Group Option the Classifier will arrange a program for the terms subsequent to the fourth year.

PROGRAM IN MUNICIPAL ENGINEERING LEADING TO A BACHELOR'S DEGREE IN CIVIL ENGINEERING AND A MASTER'S DEGREE IN ENGINEERING AND PUBLIC ADMINISTRATION

The College of Engineering and the Institute of Public and Social Administration offer a combined program to meet the needs of students who plan to work in the administrative-technical positions which are to be found in many phases of governmental service.

The field of activity for which this combination of training will be most useful is that of city management. It is especially necessary in the smaller cities for a manager to be a competent engineer and in addition to be acquainted with the latest technique of public personnel and fiscal administration. There are also a number of other fields, however, such as public personnel administration, highway department administration, waterworks management, and other phases of "public works" administration, in which this combination training should be very useful.

Students who desire to follow this program must confer with the committee in charge before diverging in any manner from the regular civil engineering curriculum. Inasmuch as the demands made upon practitioners in this field of professional work are unusually exacting in certain respects, some discretion will be exercised by the committee in approving candidates for the combined program.

After being accepted for this combined program, the student is registered in the College of Engineering until the completion of his undergraduate curriculum, and then in the Horace H. Rackham School of Graduate Studies for at least a fifth year of formal course work, six months of supervised field work, and a satisfactory thesis. The curriculum in the Engineering College leads to a bachelor's degree in Civil Engineering. The satisfactory completion of the continuation program in the Graduate School leads to a master's degree in Engineering and Public Administration.

Engineering College Program.—The curriculum in the Engineering College comprises the following list of courses:

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, 6, and a course from Group II	10
Nontechnical Electives, see section 51	6
Mathematics 13, 14, 53, 54	16
Physics 45, 46	10
Chemistry 5E	5
Drawing 1, 2	6
Geology 11	4
Ch.-Met. Eng. 1 and Met. Proc. 2	5
Economics 53, 54	6
Total	68

b) *Secondary and Technical Courses*	*Hours*
Surveying 1, 2	7
Eng. Mech. 1, 2, 2*a*, 4	11
Mech. Eng. 3	4
Elec. Eng. 2*a*	4
Civil Eng. 1, 2*c*, 3, 5*a*, 10, 26, 30, 32, 40, 42*c*	24
Total	50

c) *Courses in Special Field*	
Civil Eng. 35—Sanitary Engineering Design	3
Civil Eng. 33—Sewage Disposal; or	
Civil Eng. 34—Municipal and Industrial Sanitation	3
Civil Eng. 45—Highway Traffic Control	2
Land. Arch. 102—City Planning	2
Econ. 71, 72—Accounting	6
Pol. Sci. 107—American Government	3
Pol. Sci. 142—Municipal Government	3
Total	22
Grand Total	140

Graduate School Program.—The continuation program in the Graduate School includes at least 30 hours of course work, six months of supervised internship in some public service department, and a thesis, all under the supervision of the committee in charge. The course work should ordinarily be chosen from the following list:

	Hours
Pol. Sci. 271, 272—Advanced Public Administration	6
Econ. 174—Government Accounting	3
Econ. 121, 122—Labor	6
Econ. 181, 182—Public Finance. Taxation	6
Econ. 175—Economic Statistics	3
Civil Eng. 27—Public Utility Problems	2
Civil Eng. 31—Water Purification	2
Civil Eng. 33—Sewage Disposal; or	
Civil Eng. 34—Municipal and Industrial Sanitation	3
Civil Eng. 42*b*—Bituminous Materials	2
Civil Eng. 46—Highway Administration	2
Mech. Eng. 4—Hydraulic Machinery	3
Mech. Eng. 9—Power Plants	3
Mech. Eng. 17—Pumping Machinery	3
Mech. Eng. 25—Heating and Ventilation	2
Elec. Eng. 7*a*—Building Illumination	1
Elec. Eng. 11—Power Plants and Transmission Systems	5
Law—Municipal Corporations	2
Hygiene 203—Applied Hygiene and Public Health	2

Committee in Charge.—During his fourth year in the College of Engineering and his period of registration in the Graduate School the student will be under the general supervision of a committee made up of members from the College of Engineering and the Institute of Public and Social Administration, for counsel and advice and for aid in carrying forward his program. Requests for minor changes and modifications in either the undergraduate curriculum or the graduate program will be considered by this committee.

COURSES IN GEODESY

1. **Geodesy.** Introductory course; history; elements of modern practice and its application to several branches of surveying. Lectures, text, recitation. *Prerequisite: Surv. 3.* Three hours credit.

2. **Geodesy.** Methods employed and field covered by the United States Coast and Geodetic Survey. Lectures, reference work. *Prerequisite: Geod. 1.* Two hours credit.

COURSES IN SURVEYING

1. **Surveying.** Fundamental theory and practice. *Prerequisite: Math. 14.* Three hours credit.

2. **Surveying.** Topographic field work; stadia; plane table. *Prerequisite: Surv. 1.* Four hours credit.

3. **Surveying.** Field problems, five and one-half days a week, for 8 weeks. *Prerequisites: Surv. 1 and 2, or 12 and 13.* Eight hours credit. Summer Camp.

4. **Surveying.** Elementary theory and practice; use of instruments. Lectures, text assignments, recitation, and field exercises. *Prerequisite: Math. 14.* Two hours credit.

5. **Least Squares.** Theory of least squares; adjustment and comparison of data. Lectures, text, problems, recitations. *Prerequisite: Math. 54.* Two hours credit.

6. **Surveying.** Special advance work can be provided for those who have received credit in Surveying 3. Given only at Camp Davis. Credit, two to eight hours, depending upon the character of the work.

7. **Municipal Surveying.** Surveys for streets, grades, paving, sewers, property lines, subdivisions. Lectures, text, drawing, field period. *Prerequisite*: *Surv. 3.* Two hours credit.

9. **Railway Surveying.** Text, field, track problems. One recitation and one four-hour field period. *Prerequisite: Surv. 3, except for students in transportation.* Two hours credit.

12. **Surveying.** Similar to Surveying 1 with drawing work added. Designed for forestry students. Lectures, text, recitations, field. *Prerequisite: Math. 13.* Four hours credit.

13. **Surveying.** Similar to Surveying 2. Designed for forestry students. Lectures, text, two recitations, and two four-hour field or drawing periods. *Prerequisite: Surv. 12.* Four hours credit.

21. **Photography. Basic Course.** Fundamental theory and practice. Lectures, reference work, and laboratory period. *Prerequisites: elementary chemistry and physics.* Three hours credit.

22. **Advanced Photography.** Continuation of Surv. 21. Lectures, reference work, laboratory period. *Prerequisite: Surv. 21.* Two hours credit.

23. **Aerial Photography and Mapping.** Map projections and map making from aerial photographs. Lectures, reference work, recitations, problems, and laboratory. Two hours credit.

34. **Registration of Land Titles.** Torrens Act of Australia and modifications as adapted to conditions of other countries. Lectures, reference work. *Prerequisite: Surv. 3.* Three hours credit.

35. **Boundary Surveys.** Problems relating to the establishment of boundaries. Lectures, reference work. *Prerequisite: Surv. 3.* Three hours credit.

COURSES IN CIVIL ENGINEERING

The courses described below are identified by letters and course numbers. Thus, Civil Engineering, Course 2, is identified as Civil Eng. 2. Also Civil Eng. 65, etc.

Structural Group, Civil Eng. 1 to Civil Eng. 9.
Hydraulic Group, Civil Eng. 10 to Civil Eng. 19.
Sanitary and Municipal Group, Civil Eng. 30 to Civil Eng. 39.
Transportation Group, Civil Eng. 40 to Civil Eng. 58.
Graduate Group, Civil Eng. 60 to Civil Eng. 67.

1. **Structural Drafting.** Graphical methods of presenting and recording civil engineering data. Lectures, text, and laboratory. *Prerequisite: Draw. 2.* Two hours credit.

2. **Theory of Structures.** Analysis of stresses in simple structures. Calculation of reactions, shear, and bending moment due to fixed and moving loads. Analysis of stresses and design of simple wood, steel, and reinforced concrete structures. Lectures, text, and home problems. *Not open to civil engineering students. Prerequisite: Eng. Mech. 2.* Three hours credit.

2c. **Theory of Structures.** Analysis of stresses in simple structures. Calculation of reactions, shear, and bending moment in simple, restrained, and continuous beams due to fixed and moving loads. Analysis of stresses in simple trusses due to fixed and moving loads. Lectures, text, and home problems. *Prerequisite: Eng. Mech. 2.* Three hours credit.

3. Reinforced Concrete. Properties of materials; analysis of stresses in plain and reinforced concrete structures. *Must be preceded or accompanied by Civil Eng. 2c.* Three hours credit.

4. Advanced Theory of Structures. A continuation of Civil Eng. *2c.* Analysis of stresses in advanced types of trusses; statically indeterminate structures; arches. Lectures, texts, problems. *Prerequisite: Civil Eng. 2c.* Two hours credit.

5a. Elementary Design of Structures. Theory of beams and plate girders, and elements of design of simple structures. Computations, drawing work. *Must be preceded by Civil Eng. 1 and preceded or accompanied by Civil Eng. 2c.* Three hours credit.

5b. Design of Structures. Design of reinforced concrete and steel structures. Computations, drawing work. *Prerequisites: Civil Eng. 3 and 5a.* Three hours credit.

5c. Design of Arc-Welded Steel Structures. Elastic behavior of welded structures; designing for continuity and elastic-frame action; stress distribution in joints; expansion, contraction, distortion, and residual stresses; welding technic, methods, and equipment. *Prerequisite: Civil Eng. 5a.* One hour credit.

6. Applied Soil Mechanics. A study of soil as an engineering material; pressure distribution; determination of physical properties; bearing capacity; design of substructures, pile foundations, and underground structures; earth-pressure theories. Lectures and references. *Prerequisite: Civil Eng. 3. Should be accompanied by Civil Eng. 42d.* Three hours credit.

7a. Bridge Engineering. The selection of the proper bridge structure for a given location; economics of bridge types; determination of waterways; erection methods. *Prerequisite: Civil Eng 5a.* Two hours credit.

7b. Structural Engineering Design. Reinforced concrete building design; drafting-room practice in the general design and detailing of reinforced concrete. Lectures, drawing work. *Prerequisite: Civil Eng. 5b.* Three hours credit.

7c. Bridge Design. The design of reinforced concrete and steel highway and railway bridges. Lectures, computations, and drafting. *Prerequisite: Civil Eng. 5b.* Three hours credit.

7d. Timber Construction. Physical characteristics of structural woods; grading rules; design of timber structures. *Prerequisite: Civil Eng. 5a.* One hour credit. Summer and fall terms.

7h. Rigid-Frame Structures. Analysis of rigid frames by methods of successive approximations and slope deflections; special problems in the design of continuous frames. Lectures, references, problems. *Must be preceded or accompanied by Civil Eng. 5b.* Three hours credit.

7i. **Mechanical Methods of Stress Analysis.** The mechanical analysis of stresses in structures by means of models. *Must be preceded or accompanied by Civil Eng. 7h.* One hour credit.

7j. **Foundations and Underground Construction.** Design of substructures; investigation of foundations; earth pressure in the deep underground; excavation problems; tunnel construction and design. *Must be preceded by Civil Eng. 6, and preceded or accompanied by Civil Eng. 42d.* Two hours credit.

8. **Construction Methods and Equipment.** Contractors' organizations; laws of management; plant selection, and layout; methods of construction. Lectures, class discussion. *Open to seniors and graduates.* Two hours credit.

9. **Cost Analysis and Estimating.** Elements of cost in construction; determination of unit costs; analysis of cost records; estimates of cost; quantity surveys. Lectures, references, problems. *Open to seniors and graduates.* Two hours credit.

10. **Hydrology.** A study of the relationship between rainfall and runoff. Two recitations and one three-hour laboratory period. Three hours credit.

11. **Hydraulics.** Principles of uniform and nonuniform flow in open channels; critical depth; hydraulic jump; waves; etc. Lectures, problems. *Prerequisite: Eng. Mech. 4* Two hours credit.

12. **Water-Power Engineering.** Hydraulics of turbines and fundamental principles of water-power development. Lectures, recitations, problems. *Must be preceded or accompanied by Civil Eng. 10. Open only to seniors and graduates.* Two hours credit.

14. **Hydraulic Structures.** Dams, head gates, canals, flumes, pipes, breakwaters, and other structures; principles of irrigation, drainage, and harbor design. *Prerequisite: Civil Eng. 10.* Three hours credit.

15. **Hydraulic Models.** A study of the use of hydraulic models; principles of dimensional analysis and hydraulic similitude and applications to hydraulic problems. *Open to advanced seniors and graduate students.* Two hours credit.

16. **Hydraulic Engineering Design.** Design of hydraulic structures; dams; regulating works, etc. Lectures, computations, design. *Must be preceded by Civil Eng. 3, and preceded or accompanied by Civil Eng. 11.* Three hours credit.

20. **Legal Aspects of Engineering.** Agency, partnership, private and municipal corporations, rights in land, mechanics' liens, workmen's compensation, sales, patents, and copyrights. Cases, lectures, discussion. *Open only to seniors and graduates.* Three hours credit.

[21. **Patent Law for Engineers.** Omitted in 1942–43.]

26. **Specifications, Contracts, and Professional Conduct.** Engineering relations; ethics; war and civil contracts, and specifications. Lectures, reading, discussion. *Open to juniors, seniors, and graduates in engineering and in business administration.* Two hours credit.

27. **Public Utility Problems.** Relation of public service corporations to the public; organization; ownership; valuation; depreciation; accounting; regulation; taxation; rates; problems of different utilities. Lectures, library reading. *Open to fourth- and fifth-year students.* Two hours credit.

30. **Waterworks.** A general study of municipal water supply. Quantity required and quality necessary for various purposes; public health relationships; sources of supply; impounding reservoirs; wells; intakes; aqueducts and pipe lines; purification works; distribution; fire protection. Lectures, problems. *Prerequisite: Eng. Mech. 4. Open to seniors and graduates.* Three hours credit.

31. **Water Purification.** Relates to engineering methods and devices for improving the sanitary quality and economic value of municipal water supplies; processes of sedimentation; use of coagulants; filtration; softening; iron removal; sterilization; devices and structures for accomplishing these. Lectures, library reading, and visits to municipal water-purification plants. *Prerequisite: Civil Eng. 30. Open to seniors and graduates.* Two hours credit.

32. **Sewerage and Drainage.** Functions and purposes of sewerage and drainage systems; health relationships; principles of design of sanitary, storm-water, and combined sewers; trunk sewers, intercepting sewers, inverted siphons, and other special structures; groundwater infiltration and its effects; sewer assessments; proper treatment and final disposal of sewage. Lectures, problems. *Prerequisite: Eng. Mech. 4. Open to seniors and graduates.* Two hours credit.

33. **Sewage Disposal.** A broad survey of the engineering, public health, legal, and economic problems involved in the disposal of city sewage and industrial wastes. Lectures, library reading, and visits to nearby disposal plants. *Prerequisite: Civil Eng. 32. Open to seniors and graduates.* Three hours credit.

34. **Municipal and Industrial Sanitation.** The scientific foundations of public sanitation, in particular relation to closely built up

areas and to industrial environments. Lectures, library reading. *Open to seniors and graduates.* Three hours credit. Summer and fall terms.

35. **Sanitary Engineering Design.** Computations and drawing-board design of pipe lines, large conduits, typical structures in reinforced concrete related to water supply, water purification, sewerage, and sewage disposal. Drawing room and visits to plants and work under construction. *Must be preceded by Civil Eng. 3, and accompanied or preceded by either Civil Eng. 31, 33, or 34.* Three hours credit.

36. **Public Water Supply.** Deals with some of the broader aspects of public water supply, such as the conservation and protection of sources of supply, accepted water-supply standards, purposes and results of water purification, legal rights and responsibilities of public water-supply departments, and waterworks administration. Text, lectures, library reading. *Open to seniors and graduates.* Three hours credit.

37. **State Health Department Engineering Practice.** A critical and analytical study of the jurisdictions, functions, standards, and activities of engineering divisions of state departments of health. *Open to seniors and graduates.* Two hours credit.

40. **Highway Engineering.** Historical development; economics; preliminary investigations; design of road and street systems and the individual highway; military roads; construction and maintenance of roads and pavements. *Not restricted to engineering students.* Two hours credit.

41. **Advanced Highway Engineering.** A seminar course dealing with special phases in which the individual student may be particularly interested. Assigned reading, reports, consultation at stated intervals. Two hours credit.

42a. **Highway-Materials Laboratory.** Sources, production, and testing of highway materials; specifications; minor research problems. Lectures, text, laboratory. *Must be preceded or accompanied by Civil Eng. 40. Open to juniors, seniors, and graduates.* Two hours credit.

42b. **Bituminous-Materials Laboratory.** Sources, production, and testing of bituminous materials; theory of bituminous pavements; design of mixtures. Lectures, text, laboratory. *Prerequisite: Civil Eng. 40. Open to juniors, seniors, and graduates.* Two hours credit.

42c. **Concrete Mixtures.** Theory and design of concrete mixtures; analysis of aggregate grading; bulking due to moisture; strength, permeability, durability, yield, and economy. Discussions, problems, laboratory. One hour credit.

42d. Soil-Mechanics Laboratory. Laboratory soil tests; demonstrations and analysis of field tests; soil surveys; soil classification. *Must be preceded or accompanied by Civil Eng. 6.* One hour credit.

43. Soils in Highway Engineering. Physical properties of soil as they affect the design and construction of highways. Soil surveys and highway design; drainage, frost action, stabilization; mechanics of flexible surfaces; fills; embankments; swamp construction. *Must be preceded or accompanied by Civil Eng. 6 and Civil Eng. 42d.* Two hours credit.

44. Highway Transport. Fundamentals of transportation of passengers and commodities over highways; regulation of motor carriers; management of transportation companies. *Open to seniors and graduates. Not restricted to engineering students.* Two hours credit.

45. Highway-Traffic Control. Causes of, and remedies for, street traffic congestion and accidents. *Open to seniors and graduates. Not restricted to engineering students.* Two hours credit.

46. Highway and Railway Economics. Economics of highway and railway location, construction, and operation. Highway and railway finance. Effect on cost of grades, curves and distance. *Open to seniors and graduates. Not restricted to engineering students.* Three hours credit.

47. Highway-Traffic Surveys. Traffic studies for highway planning and for the facilitation and safeguarding of traffic flow. Assigned reading and field work. *It is desirable that this course be preceded or accompanied by Civil Eng. 45. Open to seniors and graduates.* Two hours credit.

50. Railroad Engineering. Civil and military railways; design, construction, and maintenance. Lectures, text, problems. *Open to juniors and seniors, but not restricted to engineering students.* Two hours credit.

[**51. Economics of Railroad Construction and Operation.** Omitted in 1942-43.]

[**52. Railroad Maintenance.** Omitted in 1942-43.]

[**52a. Heavy Excavation and Tunnel Work.** Omitted in 1942-43.]

53. Terminal Design. Design of railroad, highway, waterway, and airport terminals, joint terminals, layout of the various types of yards, and traffic facilities. Text, problems, drawing room. *Open to juniors, seniors, and graduates.* Three hours credit.

53a. Airport Design and Construction. Location and size of airports; design of runways; materials, types of construction for paved areas. Lectures, assigned reading, problems. *Open to juniors and seniors.* Two hours credit.

54. **Railway- and Highway-Location Design.** Field and office practice of location and construction. Text, field work, and drawing room. *Open to juniors, seniors, and graduates.* Three hours credit.

[55. **Advanced Terminal Design.** Omitted in 1942-43.]

[56. **Advanced Railroad Location.** Omitted in 1942-43.]

[57. **Railroad Administration.** Omitted in 1942-43.]

58. **Transportation.** History of transportation; relation of highway, waterway, railway, and airway transportation. Lectures, library research, seminar. *Open to juniors, seniors, and graduates, but not restricted to engineering students.* Two hours credit

60. **Sanitary Engineering Research.** Assigned work upon some definite problem related to public sanitation; a wide range in both subject matter and method is available, covering field investigations, experimentation in the laboratory, searches in the library and among public records, and drafting-room designing. By appointment. *Open to graduates only.* Credit to be arranged.

61. **Hydrological Research.** Assigned work on some special problem in the field of hydrology. An enormous amount of data is available for such studies. *Prerequisite: Civil Eng. 10. Open only to graduates.* Credit to be arranged.

63. **Civil Engineering Research.** Assigned work in the fields of transportation, public utilities, or engineering relations and ethics. To obtain credit a thesis must be prepared which would be acceptable for publication. *Open only to graduates.* Credit to be arranged.

64. **Hydraulic Engineering Research.** Assigned work in hydraulic research; a wide range of matter and method permissible. *Prerequisite: Civil Eng. 11. Open only to graduates.* Credit to be arranged.

65. **Structural Engineering Research.** Assigned work in structural engineering, as approved by the professor of structural engineering. A wide range of subject matter is available, including laboratory and library studies. *Open only to graduates.* Credit to be arranged.

66. **Highway-Engineering and Highway-Transport Research.** Assigned work in the fields of highway engineering, highway transport, or highway-traffic control. To obtain credit a thesis must be prepared which would be acceptable for publication. *Open only to graduates.* Credit to be arranged.

67. **Railroad-Engineering Research.** Assigned work in the field of railroad engineering. To obtain credit a thesis must be prepared which would be acceptable for publication. *Open only to graduates.* Credit to be arranged.

56. ELECTRICAL ENGINEERING

Professors BAILEY, HIGBIE, LOVELL, CANNON, MOORE, and ATTWOOD; Associate Professors STOUT, DOW, and GAULT; Assistant Professors BULL and HOLLAND.

Electrical engineers practice in a field of such great breadth that complete classification of subject matter and functional duties is difficult. The main subdivisions in which training is offered by the Department may be mentioned briefly. Electrical power engineering has to do with the theoretical and practical phases of power generation, distribution, and utilization. Electrical communication deals with the transmission of signals, speech, music, and pictures by open-wire lines, by cable, and by radio. Illumination engineering is concerned with the problems arising in the production and utilization of light in accordance with correct principles of physics, economics, physiology, psychology, and art. Design involves the application of the fundamentals of electricity and heat to the production of new or improved electrical apparatus. Electronics deals with the individual and statistical behavior of electrons, ions, and atoms in various types of electrical equipment, in order to permit a rational analysis of the action in electron tubes, switches, rectifiers, welding processes, etc. Industrial electrical engineering includes the study of applications and control of electricity in industrial plants.

The Electrical Engineering Department offers basic courses in the subjects enumerated above. In addition, the staff is pleased to offer guidance and laboratory facilities to graduate students who wish to work on research problems leading to one of the higher degrees.

FACILITIES

The Electrical Engineering Laboratories include a dynamo laboratory, communication laboratories, a photometric laboratory, an electronics and high-voltage laboratory, a heat-transfer laboratory, and an electrical standards laboratory.

The Dynamo Laboratory is fully equipped with direct- and alternating-current motors, generators, and control of various types, and includes the necessary complement of meters and oscillographs. The communication laboratories are well equipped with oscillators, vacuum-tube voltmeters, impedance bridges, cathode-ray oscillographs, and artificial telephone lines and cables. The photometric laboratory provides facilities for class exercises and research work in the characteristics of light sources and in the study by models of the interior lighting of buildings. The electronics and high-voltage laboratory contains a 70,000-volt surge generator, a 60,000-volt cathode-ray oscillograph, and other equipment needed to study electric-arc behavior, transient features of igniter-rods and controlled rectifiers, etc. The electrical-standards laboratory is provided with standards of resistance, inductance, and capacitance, standard cells, and other equipment needed to calibrate meters and instrument transformers. The heat-transfer laboratory offers a beginning in heat-transfer study, and is unique in possessing a Hydrocal—a hydrodynamic device for solving heat-transfer problems.

REQUIRED COURSES

The required courses offered by the department are designed to give every electrical student a thorough basic training in the principles of electrical engineering. The aim is to develop well-rounded engineers rather than narrow technicians. The staff of the Department of Electrical Engineering, by constant study and revision of course content and teaching method, aims to offer such work as will react to the ultimate benefit of the student rather than to his immediate gain. Throughout, the teaching of theory and its modifications by practice, the development of analytic judgment, and the acquiring of a fundamental scientific background are emphasized. The acquisition of specific factual knowledge is left, except where necessary to sound pedagogy, to the training in actual experience through which every electrical graduate must go during his first years out of school.

Scholarships and fellowships are available at the University for assignment to students of outstanding ability and high scholastic standing. Any electrical student desiring to ascertain the possibilities in this respect, or to make application, should consult the Chairman of the Electrical Engineering Department. Application for a Graduate School fellowship must be made before March 1. See sections 28 and 29.

CHOICE OF ELECTIVE WORK

With regard to electives in the nontechnical group, the student is advised to select such courses in the arts and sciences as will contribute to a broad, liberal education. Students feeling the lack of sufficient facility in the use of English are strongly urged to elect advanced courses in this subject, as the ability to speak and write good English is essential to a broad education in general, as well as to the highest success in the engineering profession.

The Electrical Engineering Department does not have a rigid group-election system, but considers the needs and interests of each student individually. The student should begin as early as possible to plan his course elections so that they may form a consistent and unified program of the greatest possible value. He will be aided and advised by the members of the staff.

Electrical Engineering 9 or 18 may be added to any of the programs. These courses cover individual research problems which may be selected in accordance with the wishes of the student, and which may be conducted by laboratory or library work, or by analytical study. The election may be for any number of hours approved by the instructor involved, with consideration of the suitability to the student's program. Electrical Engineering 9 is intended for undergraduates, and involves rather close faculty supervision. Electrical

Engineering 18, intended for graduates, involves independent work with little supervision, and requires a report in the form of a thesis.

Advice to Students of other colleges and universities with regard to planning their courses before coming to the University is given in section 7.

Military and Naval Science.—The attention of prospective students in electrical engineering is called to the Reserve Officers' Training Corps. Work offered in the Signal Corps group is of special interest to students in electrical engineering, as they are well qualified for it. Those who consider taking military or naval science are urged to enroll at the beginning of their course. For further details see sections 46 and 49.

CURRICULUM IN ELECTRICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Electrical Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives	6
Math. 13, 14, 53, 54, 57	18
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2 and Ch.-Met. Eng. 1	5
Economics 53, 54	6
Total	68

b) *Secondary and Technical Courses*	
Physics 147, Electrical Measurements	4
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Eng. Mech. *2a,* Laboratory in Strength of Materials	1
Eng. Mech. 3, Dynamics	3
Eng. Mech. 4, Fluid Mechanics	3
Civil Eng. 2, Theory of Structures	3
Mech. Eng. 2, Elements of Machine Design	3
Mech. Eng. 3, Heat Engines	4
Mech. Eng. 3*a*, Laboratory	1
Elec. Eng. 1, Prin. of Electricity and Magnetism	4
Elec. Eng. 2, D.C. Apparatus and Circuits	4
Elec. Eng. 3, A.C. Circuits	4
Elec. Eng. 4, A.C. Apparatus	4
Elec. Eng. 5, Design of Electrical Machinery	4

	Hours
Elec. Eng. 7, Illumination and Photometry	2
Elec. Eng. 11, Power Plants, Transmission and Distribution	5
Elec. Eng. 12, Electronics and Electron Tubes	4
Elec. Eng. 17, Electromechanics	4
Total	64

Summary:

Preparatory Courses	68
Secondary and Technical Courses	64
Electives from Suggested Groups	8
Total	140

PROGRAM

Students who earn an average grade of B, 3.0 average, on the first-term program may complete the requirements in eight terms rather than in the nine terms indicated. See Rules Governing Election of Studies, section 19*a*.

FIRST TERM		SECOND TERM	
COURSES	HOURS	COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4	Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 1	3	*English 3	2
*English 2	1	*English (Group II)	2
Drawing 1	3	Drawing 2	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5	†Ch.-Met. Eng. 1 and Metal Proc. 2 or Chem. 5E	5
Assembly	0	Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1	‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17		16 or 17

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

THIRD TERM

COURSES	HOURS
Math. 53	4
Phys. 45	5
Draw. 3	2
Eng. Mech. 1	3
Nontechnical Electives	3
Mil. or Nav. Sci.	(1)
	(18) or 17

FOURTH TERM

COURSES	HOURS
Math. 54	4
Phys. 46	5
Elec. Eng. 2	4
Nontechnical Electives	3
Mil. or Nav. Sci.	(1)
	16 or (17)

FIFTH TERM

COURSES	HOURS
Elec. Eng. 3	4
Mech. Eng. 3	4
Math. 57	2
Eng. Mech. 2	4
Eng. Mech. 2*a*	1
	15

SIXTH TERM

COURSES	HOURS
Elec. Eng. 1	4
Elec. Eng. 12	4
Mech. Eng. 3*a*	1
Eng. Mech. 3	3
Eng. Mech. 4	3
	15

SEVENTH TERM

COURSES	HOURS
Economics 53	3
Elec. Eng. 4	4
Elec. Eng. 7	2
Elec. Eng. 17	4
Elective	2
	15

EIGHTH TERM

COURSES	HOURS
Economics 54	3
Elec. Eng. 5	4
Mech. Eng. 2	3
English (Group III)	2
Elective	3
	15

NINTH TERM

COURSES	HOURS
Elec. Eng. 11	5
Civil Eng. 2	3
Phys. 147	4
Elective	3
	15

CO-OPERATIVE COURSE IN ELECTRICAL ENGINEERING AND INDUSTRY (FIVE YEARS)

The co-operative plan enables a student who is permitted to enter the course to work for fifteen months, divided into four periods, with some industrial concern, where he is rotated through various departments as a cadet engineer. Upon completion of the industrial work and of the University credit requirements of 132 hours, the student will receive 8 credit hours (in place of University elective courses), giving him 140 hours required for the bachelor's degree. About five calendar years are required for the course.

Permission to enter the course is granted only to those students who have received at least one term's University credit with a grade average distinctly above the passing requirement, and for whom definite arrangements have been made with some particular industrial concern. While with the concern the co-operating student receives wages which are satisfactory for a training course but are not intended to be sufficient to enable the student to work his way through the University. If mutually agreeable to the co-operating student and industrial concern, this course may lead to permanent employment.

Co-operative relation is established only with such industries as are able and willing to offer a definite program of work of educational value. No credit, therefore, is given for industrial work except as arranged under the co-operative plan.

COURSES IN ELECTRICAL ENGINEERING

1. **Principles of Electricity and Magnetism.** Mathematical and physical treatment of force actions and energy relations in electrostatic and electromagnetic fields; capacitance and inductance of systems of conductors; development of systems of electric and magnetic units. Three lectures and one three-hour computing period. *Prerequisites: Math. 54 and Phys. 46.* Four hours credit.

2. **Direct-Current Apparatus and Circuits.** Fundamental theory of motors and generators; electric- and magnetic-circuit calculations; power losses and efficiency of machines. Two lectures, one three-hour computing period, and one four-hour laboratory period. *Must be preceded or accompanied by Phys. 46.* Four hours credit.

2a. **Direct- and Alternating-Current Apparatus and Circuits.** Characteristics of direct- and alternating-current motors and generators; problem work on these and on electric circuits. A general course for nonelectrical students. Three lectures and one four-hour laboratory period. *Not open to electrical engineering students. Required of all other students in engineering. Prerequisites: Math. 54 and Phys. 46.* Four hours credit.

3. **Alternating-Current Circuits.** A study of alternating-current circuits, including single-phase series and parallel connections, polyphase circuits, balanced and unbalanced; e.m.f.'s in generator windings; transformers. Two lectures, one four-hour computing period, and one four-hour laboratory period. *Prerequisite: Elec. Eng. 2 or 2a.* Four hours credit.

4. **Alternating-Current Machinery.** Principles of the synchronous machine, the induction machine, the synchronous converter, and the various types of single-phase motors. Lectures, recitations, computing period, and one four-hour laboratory period. *Prerequisite: Elec. Eng. 3.* Four hours credit.

5. **Fundamentals of Electrical Design.** Design problems from various types of apparatus involving the electric and magnetic circuits; field mapping; heat-transfer and temperature-rise work. Two lectures and two four-hour computing periods *Prerequisites: Elec. Eng. 1 and 3.* Four hours credit.

6. **Advanced Theory of the Induction Motor.** Continuation of Elec. Eng. 4. Both polyphase and single-phase motors are studied.

One lecture and one three-hour computing period. *Prerequisite: Elec. Eng. 4.* Two hours credit.

7. Illumination and Photometry. Concepts, quantities, units; theory and use of typical measuring devices; calculation of illumination from point, line, and surface sources of light; laws of vision as they affect lighting; characteristics of lamps; industrial, office, school, and residence lighting. Two lectures and one three-hour laboratory period. *Must be preceded by Phys. 46, and preceded or accompanied by Math. 54.* Two hours credit.

7a. Building Illumination. A study of proper illumination for typical interiors such as schools, offices, and residences. This course is designed to acquaint students of public health, factory administration, and architecture with criteria for determining whether the lighting is good or harmful to the eyes. One illustrated lecture each week and one or two demonstration periods during the term. *Not open to electrical engineering students.* One hour credit.

8. Principles of Electric Traction. Traffic studies, train schedules, speed-time and power curves, locomotive-train haulage, signal system, cars and locomotives, control systems, traction systems, electrification of trunk lines. Recitations and problems. *Prerequisite: Elec. Eng. 3 or 2a.* Two hours credit.

9. Directed Research Problems. Special problems are selected for laboratory or library investigation with the intent of developing initiative and resourcefulness. The work differs from that offered in Elec. Eng. 18 in that the instructor is in close touch with the work of the student. Elec. Eng. 9 may be elected by seniors who have suitable preparation. Elec. Eng. 18 is for graduates. *Prerequisite: Elec. Eng. 3.* Credit by arrangement.

10. Advanced Theory of Electrical Circuits. Mathematical analysis of electrical filters; transmission of electric waves on lines; reflection at terminals. Lectures. *Prerequisite: Elec. Eng. 17.* Three hours credit.

11. Power Plants and Transmission Systems—Economics of Design. Economic features of power-plant design; economic decay, obsolescence, load division between units, plant location, conductor section, selection of circuit-breakers and reactors. Lectures, recitations, and problems. *Prerequisite: Elec. Eng. 2a or 3.* Five hours credit.

12. Electronics and Electron Tubes. Amplifier principles, gain, distortion, efficiency, coupling; oscillators; thermionic emission; grid control. Atomic energy-level diagrams, ionization and excitation potentials. Three lectures and one three-hour laboratory period. *Must be preceded by Elec. Eng. 3 and preceded or accompanied by Elec. Eng. 1.* Four hours credit.

15. **Advanced Lighting.** Selection by the student of a topic, with instructor's approval, for continued and intensive study; short oral reports by each student to the class each week; written report and bibliography presented to instructor at end of course. *Must be preceded by Elec. Eng. 7, and perceded or accompanied by Elec. Eng. 3.* Two hours credit.

16. **Electrical Rectification.** Equipment and circuits used for rectification; study of wave forms in circuits composed of resistance, inductance, capacitance, and batteries. Transformer connections, single phase and polyphase. Lectures and recitations. *Must be preceded by Elec. Eng. 12, and preceded or accompanied by Elec. Eng. 17.* Two hours credit.

17. **Electromechanics.** Analysis of complex alternating-current waves; the method of the complex variables in a.-c. problems; the application of differential equations to solutions of simple transients; use of hyperbolic functions in solving long-line problems. Lectures and problems. *Prerequisite: Elec. Eng. 3.* Four hours credit.

18. **Research Work in Electrical Engineering.** Students electing the course, while working under the general supervision of a member of the staff, are expected to plan and carry out the work themselves, and to make a report in the form of a thesis. Research. *Elected by permission of head of department.* Credit by arrangement.

19. **Study of Design—Power Plants.** Study of modern power-station design and performance. Detailed study of electrical equipment. Special problems of interconnection, frequency control, stability, single-phase, short-circuit study through use of symmetrical components. *Prerequisites: Elec. Eng. 11 and 17.* Two hours credit.

20. **Study of Design—Electric Transmission and Distribution Systems.** Mechanical features of conductors and supports. Electrical studies of lines; inductance by g.m.d. method, capacitance, equivalent circuits, and circle diagrams. Distribution systems. Surges. Lectures and recitations. *Prerequisites: Elec. Eng. 11 and 17.* Two hours credit.

21. **Ultrahigh-Frequency Techniques.** Theory and practice of short-wave techniques. Ultrahigh-frequency negative-grid tubes and circuits; Barkhausen oscillator; velocity modulation tubes, and circuits with special emphasis on the Klystron. Electromagnetic waves; Maxwell's theory; antennas and arrays. Propagation of waves at higher frequencies. Wave guides; cavity resonance phenomena. Detection of ultrahigh-frequency waves. Lectures and laboratory. Four hours credit.

22a. **Radio Communication.** Circuit theory with special emphasis on resonant circuits. Audio-frequency and radio-frequency amplification. Transmitting and receiving circuits. *This course is* *designed to accompany Elec. Eng. 21 and cannot be taken independently.* Lectures and laboratory. Four hours credit.

23n. **Elementary Radio.** This course is of a fundamental and practical nature and emphasizes actual work with equipment and maintenance of assemblages of vacuum tubes and their related circuits. Code practice is required as part of the work. Not open to engineering and physics students. Lectures, laboratory, and code practice. *No prerequisites.* Four hours credit.

24. **Elements of Electrical Communication.** Designed for nonelectrical students who desire to obtain a general knowledge of the communication field. Lectures and laboratory. *Prerequisite: Elec. Eng. 2a or equivalent. Not open to electrical students.* Three hours credit.

25. **Electromagnetic Field Theory.** Advanced theory and problems in electric and magnetic fields, using elementary vector methods which are introduced as required. Maxwell's equations, waves, and propagation of energy. *Prerequisites: Elec. Eng. 1 and 3.* Three hours credit.

25a. **Engineering Application of Electromagnetic Field Theory.** Lorentz' equations, retarded potentials, radiation from antennas. Skin effect. Mass as a function of velocity; energy and mass. Two-dimensional field studies, conformal transformations. *Prerequisite: Elec. Eng. 25.* Three hours credit.

26. **Heaviside Operators.** Advanced theory of electrical circuits as developed by the application of Heaviside operators. Methods of circuit solutions for transients in circuits with lumped constants; circuits with distributed constants; long lines; cables. Lectures and discussions. *Prerequisite: Elec. Eng. 17.* Two hours credit.

27. **Electrical and Magnetic Properties of Materials.** Studies of the electric and magnetic properties of gaseous, liquid, and solid materials used in electrical engineering. Lectures and recitations. *Prerequisites: Elec. Eng. 12 and 25.* Three hours credit.

28. **Technical Electrical Measurements.** Theory and practice in making measurements, particularly in alternating currents, to a precision and accuracy required by modern laboratories. Individual reports on various measurement problems. One afternoon of laboratory. *Prerequisite: Elec. Eng. 3* Two hours credit.

31. **Circuit Analysis by Symmetrical Components.** Representation of unbalanced polyphase currents and voltages by component symmetrical sets; solution of unbalanced circuit problems by the use of symmetrical components; faults on power systems. Lectures, recitations, and problems. *Must be preceded or accompanied by Elec. Eng. 17.* Two hours credit.

33. **Industrial Electrical Engineering.** Industrial control and motor application with short review of motor performance. Detailed study of motor and control equipment suited to particular applications. Lectures and problems. *Must be preceded by Elec. Eng. 2a, or preceded or accompanied by Elec. Eng. 4.* Three hours credit.

36. **Electric Rates and Cost Analysis.** Capitalization; fair return on investment; analysis of costs and value of electrical energy; customer charge, demand charges, energy charges; investigations of practical systems used in charging for electrical energy. Lectures. *Prerequisite: Elec. Eng. 11. Open to seniors only.* One hour credit. Spring term.

52. **Heat Problems in Electrical Design.** Advanced work in the fundamentals of heat transfer by radiation, conduction, and natural and forced convection; application to specific situations. *Prerequisite: permission of the instructor.* Two hours credit.

70. **Electrical Distribution, Wiring and Control for Lighting.** Selection and application of equipment, design of circuits, study of methods of installation for electric-power supply to lamps. Plans and specifications, analyses, and tests. Lectures, problems, and surveys. *Prerequisites: Elec. Eng. 3 and 7.* Two hours credit.

71. **Interior Illumination, Study of Design.** Unusual as well as typical designs of lighting, particularly those which have been actually built and are available for testing as a check upon the calculations, are analyzed quantitatively and qualitatively. *Prerequisite: Elec. Eng. 7 or equivalent.* Two hours credit.

73. **Photoelectric Cells and Their Applications.** Study of operating characteristics of photoelectric cells; amplifying circuits and relays; industrial applications; photoelectric photometers. Lectures and laboratory work. *Prerequisite: permission of instructor.* Two hours credit.

74. **Lighting Equipment.** Analysis of design and performance of lamps, reflectors, refractors, diffusers, and other light-control media, and of complete luminaires. Lectures and problems. *Prerequisites: Elec. Eng. 3 and 7.* Two hours credit.

81. **Theory of Grid-Controlled, High-Vacuum Thermionic Tubes.** A study of triodes and multigrid tubes; transit time effects; energy distribution and thermionic emission of electrons in metals. Two lectures and one four-hour laboratory period. *Prerequisites: Elec. Eng. 1 and 12 or equivalent.* Three hours credit.

82. **Gaseous-Conducting Electronic Apparatus.** Atomic energy-level diagrams; plasma equilibrium conditions, plasma boundaries, in electric arcs and glow discharges. Fluorescent light principles; initiation of arcs by grids and igniter rods; arc-back in rectifiers and

arc extinction in circuit-breakers. Two lectures and one four-hour laboratory period. *Prerequisite: Elec. Eng. 12 or equivalent.* Three hours credit.

83. Industrial Electronics. An applicational study of electronic circuits, methods, and problems in the manufacturing industries. *Prerequisites: Elec. Eng. 12 and 17.* Three hours credit.

84. Electron Optics. Motions of electrons and ions in electric, magnetic, and combined fields. Reflection and refraction of electron beams; principles of electrostatic and magnetic focussing. Two lectures and one four-hour laboratory. *Prerequisite: Elec. Eng. 12 or equivalent.* Three hours credit.

57. ENGINEERING MECHANICS

Professors Eriksen, Menefee, Van den Broek, Ormondroyd, and Dodge; Associate Professors Swinton, Olmstead, and Hansen; Assistant Professors Liddicoat, Everett, and Wojtaszak.

Engineering mechanics is the subject which, probably more than any other, tests the student's ability to use the technical training given him in preceding courses and at the same time prepares him for what is to follow.

No definition of engineering, from whatever angle given, is complete without some reference to forces. It is in mechanics that the student is given the engineer's conception and methods of handling forces. This is accomplished by:

a) A general required three-hour course in fundamentals, definitions, and conceptions of the ways in which mathematics, analytical and graphical, may be used with the laws of equilibrium, to solve problems dealing with the various phases of forces, followed by—

b) A required four-hour course on strength and elasticity of materials. This course is supplemented by a one-hour laboratory course.

c) A required three-hour course in dynamics, supplemented by a one-hour elective course in the laboratory.

d) A required three-hour course in fluid mechanics with a demonstration room for illustrating principles of streamline flow, channel and weirs, pipe flow, orifices, etc.

Library.—The general engineering library has books for collateral reading and study in mechanics.

The Physical Testing Laboratory occupies two adjoining large rooms with entrance at Room 102, West Engineering Building. The equipment comprises a 50,000-pound, a 100,000-pound, and a 200,000-pound tension-compression machine, a 230,000-inch-pound torsion machine with jaws for taking specimens 2⅞ inches in diameter, an Olsen impact machine, an Upton Lewis endurance tester, an electrically driven bar bender for bars up to 2½ inches in diameter, a Brinell hardness tester, a wire tester, a transverse bending machine for castiron arbitration bars and other short demonstration beams, a 9-

foot transverse bending machine and a power saw and grinder, an electric furnace, a polishing table and wheel with photographic equipment, and cement-testing equipment for all standard cement tests.

The special accessory equipment consists of one six-element telemeter strain gage, one Huggenberger extensometer, one Martens mirror strain gage, one electrical micrometer gage, one contact micrometer gage, several Berry gages, and one vertical and one horizontal portable seismograph.

CURRICULUM IN ENGINEERING MECHANICS AND REQUIREMENTS FOR GRADUATION

The following curriculum leading to the degree of Bachelor of Science in Engineering (Engineering Mechanics) has been provided to meet the increasing demand from industry for graduates with the thorough theoretical grounding in mechanics and mathematics needed to cope with difficult engineering problems of research type.

	Hours
a) *Preparatory Courses*	
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
*Nontechnical Electives	6
Math. 13, 14, 53, 54, 57	18
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2 and Chem. Eng. 1	5
Economics 53 and 54	6
Total	68
b) *Secondary Courses*	
Surveying 4	2
Eng. Mech. 1, 2, 2*a*, 3, 4	14
Elec. Eng. 2*a*	4
Civil Eng. 2	3
Mech. Eng. 3	4
Total	27
c) *Advanced Courses*	
Technical Group, in some specified technical engineering department, including an advanced design course; approximately	13
Eng. Mech. (advanced)	16
Math. Group; approximately	10
Electives; approximately	6
Grand Total	140

The number of hours in the technical, mathematics, and elective groups are subject to variation on the advice of the Chairman of the Department.

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* See Section 34.

COURSES IN ENGINEERING MECHANICS

1. **Statics.** Study of fundamental principles of mechanics and their application to the simpler problems of engineering. Forces, components, vectors, moments, couples, method of sections, cables, friction. Recitations, lectures, problems. *Must be preceded or accompanied by Math. 53 and Phys. 45.* Three hours credit. Each term.

2. **Strength and Elasticity of Materials.** A study of the application of mathematics and principles of mechanics to solution of problems in stress and strain on engineering materials, including resistance to direct force, bending, torque, shear, eccentric load, deflection of beams by area moment method, and compounding of simple stresses. Recitations, lectures, and problems. *Must be preceded by Eng. Mech. 1, and preceded or accompanied by Math. 54.* Four hours credit. Each term.

2a. **Laboratory in Strength of Materials.** Experiments with beams, struts, shafts, and engineering materials, supplementing text work. Attendance at laboratory once each week. *Must be preceded or accompanied by Eng. Mech. 2.* One hour credit. Each term.

3. **Dynamics.** All motions of a particle, dynamics of moving bodies, Newton's laws, simple harmonic motion, elementary vibration problems, balancing, pendulums, impulse and momentum, gyroscopy, and work and energy. Recitations, lectures, problems. *Prerequisites: Eng. Mech. 1 and Math. 54.* Three hours credit. Each term.

3a. **Experimental Dynamics.** Experiments with acceleration, vibration, balancing, critical speeds, and gyroscopics. One hour laboratory period, with report, each week. *Must be preceded or accompanied by Eng. Mech. 3.* One hour credit.

4. **Fluid Mechanics.** Properties of fluids; statics of fluids, compressible and incompressible; flotation; accelerated liquids in relative equilibrium; dynamics of fluids, Bernoulli's theorem, measurement of velocity and pressure; the flow of viscous fluids, thin films, discontinuity, Reynolds' number; viscometry; the flow of fluids in pipes, Reynolds' criterion; flow with free surface, channels, weirs; orifices and nozzles; impulse and momentum in fluids; resistance of immersed and floating bodies, Froude's number, boundary layer; dynamics of compressible fluids, Mach's number, cavitation, Bernoulli's theorem; dynamical similitude. Recitations, lectures, demonstrations. *Prerequisites: Eng. Mech. 1 and Math. 54.* Three hours credit. Each term.

5. **Materials Testing.** (Required only of architectural engineers.) History of rapid development of the science; correlation with mechanics; study of testing machines, calibration, and particular function. Written reports, special emphasis on technique of report

writing, and graphic presentation and interpretation of data. Laboratory work devoted to tests on steel, iron, wood, brick, and structural materials, including standard cement tests, water-ratio theory, voids in sand and gravel, reinforced and unreinforced concrete beams, and granular metric analysis of sand. Lectures, laboratory, reports. *Prerequisite: Eng. Mech. 2.* Two hours credit. Each term.

7. **Research in Testing Materials.** *Prerequisite: Eng. Mech. 2.* Credit to be arranged.

8. **Advanced Dynamics.** Advanced dynamics of rigid bodies in systems of engineering interest. Lagrange's equations. *Prerequisites: Eng. Mech. 3 and 12.* Two hours credit.

9. **Advanced Strength of Materials. Elastic Energy Theory (Least Work).** Elastic curves as influence lines. Analysis of redundant structures, trusses, frames, bents, curved beams (hair springs, arches). Lectures, problems. *Prerequisite: Eng. Mech. 2.* Three hours credit.

10. **Research in Strength of Materials.** Special problems involving laboratory tests, and application of theory in engineering mechanics. Credit to be arranged.

10a. **Research in Theory of Elasticity.** Special problems involving application of theory and experimental investigation. Credit to be arranged.

10b. **Research in Theory of Structures.** Special problems such as arches, arch dams, suspension bridges, elastic stability of columns and framed structures, impact effect and vibration of bridges. Credit to be arranged.

10c. **Research in Dynamical Problems.** Original investigations in the field of body motions. Such problems may deal with the vibrations of mechanical systems; oscillations in fluid systems; control problems which tie together fluid motion and the motion of physical bodies. These investigations may also deal with the fundamentals of mechanics, such as the study of friction, internal hysteresis of materials, and viscosity of liquids. Hours and credit to be arranged.

12. **Vibration Problems in Engineering.** Vibration of systems with one degree of freedom. Balancing of rotating machines; calculations of critical speeds of rotating shafts; theory of vibration-recording instruments; springs of variable flexibility. Systems with several degrees of freedom, and elastic bodies. Vibration of cars; torsional and lateral vibration of shafts; vibration of beams; vibration of bridges, turbine blades, and turbine discs. *Prerequisites: Eng. Mech. 1, 2, and 3, and Math. 105.* Three hours credit.

13a. **Applied Elasticity.** Fundamentals of the theory of elasticity with its application to stress analysis in machine parts. Stress and strain. General equations of equilibrium. Two-dimensional problems of the theory of elasticity and the photoelastic method of stress analysis. Stress concentration produced by fillets and holes. Stress in curved bars. Torsion of prismatical bars. Torsion of circular shafts of variable diameter. Bending of prismatical bars. *Prerequisites: Eng. Mech. 1, 2, and 3, and Math. 105.* Two hours credit.

13b. **Applied Elasticity; Theory of Thin Plates.** General equation for deflection of thin plates. Bending of circular plates under various loading conditions. Bending of rectangular plates. Buckling of plates. Application in design of tubular built-up sections and girders. Plates on elastic foundation. Designed principally for graduate students. *Prerequisites: Eng. Mech. 1, 2, and 3, and Math. 105.* Two hours credit.

14. **Advanced Stress Analysis.** Stress concentration in tension and compression produced by fillets and holes. Photo-elastic method of studying stress concentration. Stresses in shafts of variable cross-sections. Stresses due to shrink-fit pressure. Stresses in curved bars, theory and applications. Stresses in flywheels, rotating discs, and rotors. Critical speeds. Designed principally for students interested in machine design. *Prerequisite: Eng. Mech. 2.* Two hours credit.

15. **Theory of Structures in Ship Design.** With application to the solution of such problems as bending of beams on elastic foundation; combined bending and tension or compression; buckling of solid, tubular, and built-up columns under various conditions; buckling of thin plates, such as flanges and webs of built-up sections, and the web of a plate girder; bending of slabs under various conditions, with application to ship decks. Designed principally for students interested in naval architecture and marine engineering. *Prerequisite: Eng. Mech. 2.* Three hours credit.

16. **Seminar in Engineering Mechanics.** Credit to be arranged.

18. **Ductility of Materials (Theory of Limit Design).** The theory of strength and resistance of structures predicated upon the ductility of materials and buckling strength of members. *Prerequisite: Eng. Mech. 2.* Two hours credit.

20. **Mechanical Properties of Metals.** Attention is directed to the general principles rather than to a description of established, standardized methods of testing materials and manipulating apparatus. Tension and compression tests. Lüders' lines. Strain hardening. Residual stresses due to plastic flow of metals. Types of failures. Time effect and hysteresis. The fatigue of metals under cycles of stress. Causes of fatigue. Mechanical properties of metals at high temperatures. Various strength theories. Working stress. *Prerequisites: Eng. Mech. 2 and Math. 105.* One hour credit.

21. **History of Dynamics.** A review of the important publications in which the fundamental principles of dynamics were developed. *Mechanical Questions,* Aristotle. The influence of astronomical theories on the development of dynamics. *Almagest,* Ptolemy, *Revolution of the Heavenly Bodies,* Copernicus. The work of Tycho Brahe and Kepler. Leonardo da Vinci. *Two New Sciences,* Galileo; *Pendulum Clock, Centrifugal Forces, Theory of Light,* Huygens; *Principia,* Newton. The transition from the geometrical treatment to the analytical treatment of dynamical problems. Bernoulli, Euler, d'Alembert, and Lagrange. *Prerequisites: Eng. Mech. 3 and Math. 105.* One hour credit.

25. **Stability of Elastic Structures.** Bending of bars under the action of lateral and direct load. Buckling of slender bars; buckling of comparatively short bars. Effect of eccentricity and initial curvature. Practical applications of the design of columns. Stability of I-beams. Stability of thin plates under compression and shear. Application in plate-girder design. Stability of thin-walled structures. *Prerequisites: Eng. Mech. 1, 2, and 3, and Math. 105.* Two hours credit.

26. **Plasticity.** Elastic and plastic deformation. The mechanism of plastic deformation. Stain hardening. Theory of strength. Plastic deformation in tension and compression. Plastic deformation in torsion and bending. Plastic flow in hollow cylinders. Plastic flow in rotating discs. Plane plastic flow. Creep at high temperature. *Prerequisites: Eng. Mech. 1, 2, and 3, and Math. 105.* Two hours credit.

58. MATHEMATICS

Professors HILDEBRANDT, BRADSHAW, FIELD, LOVE, and CHURCHILL; Associate Professors HOPKINS, POOR, and E. W. MILLER; Assistant Professors ROUSE, DUSHNIK, RAINVILLE, and THRALL; Mr. KAZARINOFF, Dr. BARTELS, Dr. GOLDSTINE, Dr. HAY, Dr. KAPLAN, Dr. EVERETT, and Dr. THORNE.

The object of the work of this department in the College of Engineering is not only to impart to the student the mathematical knowledge requisite for the study of the various branches of engineering, but also to train his mind in methods of precise reasoning and accustom him to the proper application of general principles to particular cases.

Much time is devoted to the solution of problems in order to combine a fair knowledge of the elementary principles of higher mathematics with the necessary facility in applying these principles to concrete cases. The classes are divided into sections as small as practicable, so as to make it possible for the instructor to give his individual attention to the students.

The required work is practically the same for all students of engineering, and extends throughout the first two years. The first year is devoted to advanced algebra, and plane and solid analytic geometry; the second, to differential and integral calculus. An introduction to differential equations is required in certain departments. Students who do not have credit in solid geometry and trigonometry are required to complete these subjects as early as possible.

For students who desire to pursue their mathematical studies beyond the required work, a considerable number of advanced elective courses are offered. Courses which are of particular interest to students of engineering are listed below. Complete offerings of the Department of Mathematics will be found in the *Announcements* of the College of Literature, Science, and the Arts, and of the Horace H. Rackham School of Graduate Studies.

There is an increasing demand in the engineering industries and in the faculties of technical schools for graduates who have taken considerably more mathematics and mechanics than is required in the other engineering curricula. To meet this demand, the following program has been provided:

CURRICULUM IN MATHEMATICS AND REQUIREMENTS FOR GRADUATION

Since this curriculum leads to fields other than engineering it is not listed for accrediting with the Engineers' Council for Professional Development.

Candidates for the degree of Bachelor of Science in Engineering (Mathematics) are required to complete the following curriculum:

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives (preferably French or German)	8
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2	6
Met. Proc. 2 and Ch.-Met. Eng. 1	5
Total	60
b) *Secondary Courses*	
Eng. Mech. 1, 2, 3 (or Math. 141 and 142 in place of Eng. Mech. 1 and 3)	10
Elec. Eng. 2*a*	4
Mech. Eng. 3	4
Total	18
c) *Advanced Courses*	
Options in Mathematics including 103 or 105 and 106, and 151 or 153	12
Options in Engineering	10

	Hours
Electives in Astronomy, Chemistry, Economics, Engineering, Engineering Mechanics, Drawing, Mathematics, Metal Processing, Natural Science, Physics, and Surveying	20
Free Electives	20
Total	62
Summary:	
Preparatory Courses	60
Secondary Courses	18
Advanced Courses	62
Total	140

Students in chemical engineering or in metallurgical engineering who become candidates for degrees in chemical engineering and mathematics or in metallurgical engineering and mathematics are permitted to make the following substitutions:

1. In the mathematics curriculum substitute three hours of chemistry (beyond 5E) for Eng. Mech. 3.
2. In the chemical or metallurgical curriculum substitute three hours of advanced mathematics for Economics 173.

COURSES IN MATHEMATICS

*6. **Solid Euclidean Geometry.** Postulates; basic constructions and propositions; original exercises; mensuration. *Prerequisite: one year of plane geometry.* Two hours for no credit. Fall and spring terms.

*7. **Algebra and Trigonometry.** Review of elementary operations; linear equations; exponents; radicals; quadratic equations; simultaneous quadratics; progressions; binomial theorem. Trigonometry—the same as in Math. 8. Four hours for two hours credit. Each term.

*8. **Trigonometry.** Trigonometric ratios; trigonometric identities and equations; inverse functions; reduction and addition formulas; laws of sines, cosines, and tangents; theory and use of logarithms; solution of triangles. Two hours credit. Each term.

10 (58). **Spherical Trigonometry.** Fundamental properties of spherical triangles and trihedral angles; solution of spherical triangles, tetrahedra, and parallelepipeds; Napier's and Delambre's analogies; applications to navigation. *Prerequisites: solid geometry and plane trigonometry.* One hour credit. Fall and spring terms.

*13 (3). **Algebra and Analytic Geometry.** Review of exponents, radicals, quadratic equations; theory of equations; determinants; complex numbers; curve tracing and locus problems in Cartesian and polar co-ordinates; straight line; circle. Four hours credit. Each term.

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* Students entering with credit in trigonometry will take Mathematics 13. Students entering without trigonometry will take Mathematics 7, except that those whose high-school records show unusual proficiency in mathematics may take Mathematics 13 and 8 instead. Permission to do this must be obtained from the Department of Mathematics at the time of classification. Students entering without credit in solid geometry will take Mathematics 6 without credit.

14 (4). **Plane and Solid Analytic Geometry.** Conic sections; properties of conics involving tangents, diameters, asymptotes, parametric equations; surface tracing and locus problems in space; plane; straight line; quadric surfaces; space curves. Four hours credit. Each term.

15 (9). **Solid Analytic Geometry.** Surface tracing and locus problems in space; planes; straight lines; quadric surfaces; space curves. Two hours credit. Fall term.

20. **Introduction to Air Navigation.** Graphical and numerical methods of solving geometrical problems arising in air navigation; solution of wind diagrams, and drift on two headings; plane, Mercator, and great circle flyings; radius of action and intercept problems; bearings and fixes. An attempt will be made to cover the material presented in the Army's navigation schools, except for the usual instruction in the air. *Prerequisites: one unit each of high-school algebra and geometry.* Four hours credit. Each term.

53 (36). **Calculus I.** Functions; limits; continuity; derivative; differentiation of algebraic functions; trigonometric, exponential, and logarithmic functions; differential; curvature; time rates; introduction to the indefinite integral. Four hours credit. Each term.

54 (37). **Calculus II.** Definite integral; definite integral as the limit of a sum; centroids; moments of inertia; infinite series; Maclaurin's series; Taylor's series; partial differentiation; multiple integrals. *Prerequisite: Math. 53, or equivalent.* Four hours credit. Each term.

57 (39). **Differential Equations.** Simple types of ordinary equations of the first and second order; linear equations with constant coefficients; applications to geometry and mechanics. *Prerequisite: Math. 54.* Two hours credit. Fall and spring terms.

103. **Differential Equations.** An elementary course in ordinary differential equations, including more detailed treatment of the topics listed in Math. 57, together with the study of more general linear and nonlinear equations. *Prerequisite: one year of calculus.* Three hours credit. Each term.

105. **Differential Equations.** Solutions of differential equations by elementary methods. *Prerequisite: Math. 54.* Two hours credit. Fall term.

106. **Advanced Differential Equations.** Solution of differential equations by infinite series; functions defined by differential equations. Two hours credit. Spring term.

109. **Graphical Calculus and Differential Equations.** Graphical differentiation and integration; method of least squares; graduation of data; determination of weights of data; graphical solution of differential equations. This is mostly a problem course planned for chemical engineers. *Prerequisite: calculus.* Three hours credit. Fall and spring terms.

110. **Elementary Course in Complex Variables.** Complex numbers; limit; continuity; derivative; conformal representation; integration; Cauchy theorems; power series; singularities; applications to engineering and mathematical physics. *Prerequisite: calculus.* Three hours credit. Spring term.

127. **Theory of Statistics I.** Averages and moment characteristics of frequency distributions. Frequency functions. *Prerequisite: one year of calculus.* Three hours credit. Each term.

128. **Theory of Statistics II.** Correlation and sampling theory. *Prerequisite: Math. 127.* Three hours credit. Fall and spring terms.

130. **Significance Tests.** Theory and applications of statistical methods suitable for small samples, including quality control and the analysis of variance. *Prerequisites: Math. 127 and 128 or their equivalent.* Two hours credit. Spring term.

141. **Statics.** The fundamental concepts of mechanics, vectors, velocity, acceleration, mass and force, work and energy, center of gravity, moments of inertia. Statics of a particle, of rigid bodies, and of deformable bodies. *Prerequisites: Math. 53 and 54.* Three hours credit. Fall term.

142. **Dynamics.** Motion in a straight line, curvilinear motion, central forces, constrained motion. Generalized co-ordinates of Lagrange, canonical equations of Hamilton, general principles of mechanics. Three hours credit. Spring term.

143. **Applications of Mathematics to Engineering Problems.** Dynamics; the gyroscope, the ballistic problem, the motion of an airplane, etc. Small oscillations. The mechanics of strings; the suspension bridge. The vibration and buckling of beams. *Prerequisites: differential equations, advanced calculus recommended.* Three hours credit. Fall term.

145, 146. **Celestial Mechanics.** Rectilinear motion of a particle; central forces; potential and attraction of bodies; problem of two, three, and *n* bodies; applications of relativity; mechanical quadrature; stellar constitution; introduction to periodic orbits. Two hours credit each. Fall term, Math. 145; spring term, Math. 146.

148. **Fluid Dynamics.** Nonviscous fluids, vortex theory, wind motion on the surface of the earth, forces on air foils, viscous fluids, dynamic similarity, turbulence. This course will meet the needs of students of meteorology. *Prerequisite: Math. 54.* Three hours credit. Spring term.

149. **Exterior Ballistics.** The nature of the data on which range tables are based, the equations of motion in vacuo and in air, numerical integration, corrections for variations from range table conditions. Two hours credit. Spring term.

150. **Advanced Mathematics for Engineers.** Topics in advanced calculus including infinite series, Fourier series, partial derivatives, directional derivatives, line integrals, Green's theorem, vector analysis and complex variables. Introduction to differential equations. *Required in aeronautical engineering. Prerequisite: Math. 54.* Four hours credit. Fall and spring terms.

151. **Advanced Calculus.** Review of the fundamental theory of elementary calculus. Taylor's theorem. Explicit and implicit functions. Simple, multiple, and improper integrals. Functions defined by integrals and other selected topics. Three hours credit. Fall and spring terms.

152. **Fourier Series and Applications.** Orthogonal functions, Fourier series, Bessel functions, Legendre polynomials and their applications to boundary value problems in mathematical physics. *Prerequisite: Math. 151 or 153.* Three hours credit. Fall and spring terms.

153, 154. **Advanced Calculus I and II (Longer Course).** Review of fundamental concepts; continuity; definite and improper integrals; vector analysis; partial differential equations; calculus of variations; functions of a complex variable; elliptic integrals; Fourier series; Bessel functions. *A student may not receive credit for both Math. 151 and 153, but 154 may follow 151.* Three hours credit each. Fall term, Math. 153; spring term, Math. 154.

[157. **Intermediate Course in Differential Equations.** Linear equations of the second order. The generalized Riccati equation, the hypergeometric equation, and the confluent hypergeometric equation. Use of divergent summable series. *Prerequisites: Math. 103 or 105, and 151 or 153, or their equivalents.* Three hours credit. Omitted in 1942-43.]

169. **Graphical Methods.** Graphical representation of functions; construction of graphical charts; graphical solution of equations; graphical methods applied to the solution of differential equations. Two hours credit. Fall term.

170. **Empirical Formulas.** Curve fitting; graphical determination of constants in empirical formulas; application of the method

of least squares; interpolation; numerical integration. Two hours credit. Spring term.

[175. **Theory of the Potential Function.** Newtonian attraction, Newtonian and logarithmic potentials, the equations of Laplace and Poisson, harmonic functions, the principles of Dirichlet, the problems of Dirichlet and Neumann, and Green's function. Three hours credit. Omitted in 1942-43.]

176. **Vector Analysis.** A study of the formal processes of vector analysis, followed by applications to problems in mechanics and geometry. Three hours credit. Spring term.

[247. **Mechanics of Continua.** Derivation of the equations of motion. Application to some cases of a vibrating elastic body. The motion of a perfect fluid. Bernoulli's theorem. Vortex motion. Three hours credit. Omitted in 1942-43.]

249. **Methods in Partial-Differential Equations.** Theory and application of the solution of boundary-value problems in the partial-differential equations of engineering and physics by various methods: orthogonal functions, Laplace transformation, other transformation methods, Green's functions. Three hours credit. Spring term.

347, 348. **Seminar in Applied Mathematics.** One hour credit. Each term.

59. MECHANICAL ENGINEERING

Professors Hawley, Bursley, Lay, Sherzer, Keeler, Gordy, Vincent, and Nickelsen; Associate Professors Mickle, Good, Marin, and Lloyd; Assistant Professors Watson, Kessler, Calhoon, Kohler, Porter, Schwartz, and Spooner; Mr. Hiersch and Mr. Shideman.

Mechanical Engineering includes the fields of heat, power, design of machinery, management, and industrial problems. It may be divided into thermodynamics, steampower, internal-combustion engines, hydromechanics, heating, ventilation, air-conditioning, refrigeration, automobile, aircraft power, machine design, and industrial engineering, and covers theory, design, and laboratory work in these fields.

The Department of Mechanical Engineering stresses a thorough training in the basic courses of mathematics, physics, chemistry, drawing, English, economics, and mechanics; followed by required fundamental courses in thermodynamics, heat engines, power, laboratory practice, hydraulics, machine design, and management to supplement the foundation courses. Opportunity is given for elective courses in special fields. Graduate study is encouraged and a number of courses are outlined especially for graduate students.

FACILITIES FOR INSTRUCTION

Physical equipment in the form of laboratory apparatus for demonstration and testing is an important adjunct to classroom instruction.

The Mechanical Engineering Laboratory located in the West Engineering Building is devoted to experimental work in connection with engines, turbines, boilers, fuels, pumps, fans, air compressors, hydraulic machinery, and special equipment.

The Automotive and Internal Combustion Laboratory located in the West Engineering Annex includes twenty-five or more internal-combustion engines of several types, together with complete test equipment in the form of dynamometers, brakes, etc. Both laboratories have ample facilities for research work. A small laboratory for testing aircraft motors is located at the Ann Arbor Airport. Facilities are available also for laboratory instruction in time and motion study.

Advice to Students of other colleges and universities, with regard to planning their courses before coming to the University, is to be found in section 7.

Military and Naval Science.—Students who plan to take courses in military or naval science are urged to enroll in the beginning of the freshman year, and in doing so should consult with the officer in charge of this department, and also with the head of the department in which he proposes to take his degree. For information regarding the work see sections 46 and 49.

CURRICULUM IN MECHANICAL ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Mechanical Engineering) are required to complete the following curriculum.

For the definition of an hour of credit see section 33.

Curriculum

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives	6
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E	5
Drawing and Descriptive Geometry 1, 2, 3	8
Metal Proc. 2 and Ch.-Met. Eng. 1	5
Metal Proc. 3, Foundry	4
Metal Proc. 4, Machine Shop	4
Economics 53, 54	6
Total	74

b) Secondary and Technical Courses	*Hours*
Surveying 4, Use of Instruments	2
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Eng. Mech. 2*a*, Laboratory	1
Eng. Mech. 3, Dynamics	3
Eng. Mech. 4, Fluid Mechanics	3
Mech. Eng. 1, Introduction to Mech. Eng.	1
Mech. Eng. 1*a*, Mechanism	2
Mech. Eng. 2, Machine Design	3
Mech. Eng. 3, Heat Engines	4
Mech. Eng. 4, Hydraulic Machinery	3
Mech. Eng. 5, Thermodynamics	3
Mech. Eng. 6, Advanced Machine Design	3
Mech. Eng. 7, Laboratory, First Course	2
Mech. Eng. 8, Laboratory, Second Course	3
Mech. Eng. 9, Power Plants	3
Civil Eng. 2, Theory of Structures	3
Elec. Eng. 2*a*, D.C. App. and Cir.	4
Ch.-Met. Eng. 10, Utilization of Fuels	1
Total	51

Summary:

Preparatory Courses	74
Secondary and Technical Courses	51
Electives, Restricted and Free	15
Total	140

SELECTION OF ELECTIVE COURSES

The 15 hours of elective work are to be filled partly by "Restricted Electives" and partly by "Free Electives."

a) *Restricted Electives:*

Students taking the regular curriculum must elect at least one theory course from the following group: Mech. Eng. 11, 13, 14, 15, 16, 17, 19, 20, 25, 30, 31, 35; and must complete a design requirement from Mech. Eng. 9*a*, 11*a*, 15*a*, 16*a*, 17*a*, 20*a*, 25*a*, 30*a*, 31*a*, 62-63, 72-73. Some of the design courses require the corresponding theory course as a prerequisite. In others certain freedom of choice is permitted. In all elections, prerequisites must be followed.

b) *Free Electives:*

The remaining elective hours may be filled by courses offered by any department in the Engineering College or by any College or School in the University to which the student is eligible, subject to the approval of the head of the Mechanical Engineering Department.

In the selection of his elective hours the student is urged to broaden his training by making elections in other departments of work, and in so doing should consult freely with the members of the Mechanical Engineering staff.

PROGRAM IN MECHANICAL ENGINEERING

FIRST TERM

COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4
*English 1	3
*English 2	1
Drawing 1	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

SECOND TERM

COURSES	HOURS
Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 3	2
*English (Group II)	2
Drawing 2	3
Ch.-Met. Eng. 1 and Metal Proc. 2 or †Chem. 5E	5
Assembly	0
‡Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17

THIRD TERM

Math. 53	4
Physics 45	5
Drawing 3	2
Eng. Mech. 1	3
Mech. Eng. 1	1
Mil. or Nav. Science	(1)
	(16) or 15

FOURTH TERM

Math. 54	4
Physics 46	5
Eng. Mech. 2	4
Eng. Mech. 2*a*	1
Mech. Eng. 1*a*	2
Mil. or Nav. Science	(1)
	(17) or 16

FIFTH TERM

Mech. Eng. 2	3
Mech. Eng. 3	4
(*a*) Mech. Eng. 7 and Ch.-Met. Eng. 10	(3)
or	
(*b*) Metal Proc. 3	4
Economics 53	3
Electives	3
	16 or 17

SIXTH TERM

Eng. Mech. 3	3
Mech. Eng. 5	3
(*a*) Metal Proc. 3	4
or Mech. Eng. 7 and Ch.-Met. Eng. 10	(3)
Economics 54	3
Electives	3
	15 or 16

SEVENTH TERM

Mech. Eng. 6	3
Eng. Mech. 4	3
Elec. Eng. 2*a*	4
Civil Eng. 2	3
Electives	3
	16

EIGHTH TERM

Mech. Eng. 4	3
Metal Proc. 4	4
§Mech. Eng. Theory	(2) or 3
Mech. Eng. 9	3
Electives	3
	(15) or 16

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education twice a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

§ To be selected from Mech. Eng. 11, 13, 14, 15, 16, 17, 19, 20, 25, 30, 31, 35, 62, 72.

NINTH TERM

Mech. Eng. 8	3
†Mech. Eng. Design	3
Surveying 4	2
Eng. (Group III)	2
Electives	4
	14

Students who earn an average grade of approximately B on the first-term program may be able to complete the requirements in eight terms rather than in the nine terms indicated. See Rules Governing Elections or Studies, Section 19*a*.

COMBINED CURRICULUM IN MECHANICAL AND INDUSTRIAL ENGINEERING

This curriculum, which includes courses in economics and business administration in addition to courses in mechanical engineering, is planned as described below. The degree of Bachelor of Science in Engineering (Mechanical Engineering) is given on satisfactory completion of the prescribed 140 credit hours. The student must register in the Graduate School for the additional work and on its successful completion, the degree of Master of Science (Industrial Engineering) is awarded. *Courses listed in the graduate year cannot be elected in the undergraduate years.*

Subjects—Undergraduate	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives	7
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E	5
Drawing and Descriptive Geometry 1, 2, 3	8
Metal Proc. 2, 3, 4, 107	12
Eng. Mech. 1, 2, 2*a*, 3, 4	14
Mech. Eng. 1, 1*a*, 2, 3, 5, 6, 7, 8, 9	24
Factory Management, Mech. Eng. 20, 35, 36	8
Ch.-Met. Eng. 1, 10	4
Elec. Eng. 2*a*	4
Civil Eng. 2	3
Economics 53, 54, 71, 72, 175	15
Total	140

‖ To be selected from Mech. Eng. 9*a*, 11*a*, 15*a*, 16*a*, 17*a*, 20*a*, 21*a*, 25*a*, 30*a*, 31*a*, 63, 73.

Subjects—Graduate Year	*Hours*
Mech. Eng. 40, 42	6
Bus. Ad. 113, 161, 162, 202	12
Electives	6
Total	24

Electives. Students pursuing this program are urged to elect English 6, Report Writing, during the fourth year. Attention is further invited to the following courses which are of especial significance to industrial engineering:

Electrical Engineering 7a (Building Illumination)	1 hour
Mechanical Engineering 25 (Heating and Ventilation)	2 hours

PROGRAM IN MECHANICAL AND INDUSTRIAL ENGINEERING

FIRST TERM		SECOND TERM	
COURSES	HOURS	COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4	Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 1	3	*English 3	2
*English 2	1	*English (Group II)	2
Drawing 1	3	Drawing 2	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5	Ch.-Met. 1 and Metal Proc. 2 or †Chem. 5E	5
Assembly	0	Assembly	0
Physical Ed. or Mil. or Nav. Science	0 or 1	Physical Ed. or Mil. or Nav. Science	0 or 1
	16 or 17		16 or 17

THIRD TERM		FOURTH TERM	
Math. 53	4	Math. 54	4
Econ. 53	3	Econ. 54	3
Phys. 45	5	Phys. 46	5
Draw. 3	2	Eng. Mech. 1	3
Mech. Eng. 1	1	Mil. or Nav. Science	(1)
Mil. or Nav. Science	(1)		16 or 15
	16 or 15		

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

FIFTH TERM

COURSES	HOURS
Mech. Eng. 3	4
Ec. 71	3
Mech. Eng. 1*a*	2
Eng. Mech. 2	4
Eng. Mech. 2*a*	1
Mech. Eng. 7 and Ch.-Met. E. 10	3
	17

SIXTH TERM

COURSES	HOURS
Eng. Mech. 3	3
Mech. Eng. 5	3
Ec. 72	3
Metal Proc. 3	4
Mech. Eng. 2	3
	16

SEVENTH TERM

Mech. Eng. 35	3
Ec. 175	3
Mech. Eng.	3
Elec. Eng. 2*a*	4
Electives	3
	16

EIGHTH TERM

Mech. Eng. 36	3
Eng. Mech. 4	3
Metal Proc. 4	4
Civil Eng. 2	3
Engl. (Group III)	2
	15

NINTH TERM

Mech. Eng. 20	2
Metal Proc. 107	2
Mech. Eng. 8	3
Mech. Eng. 9	3
Electives	4
	14

GRADUATE YEAR

FIRST TERM

Bus. Ad. 161	3
Mech. Eng. 40	3
Bus. Ad. 113	3
Electives	3
	12

SECOND TERM

Bus. Ad. 162	3
Bus. Ad. 202	3
Mech. Eng. 42	3
Electives	3
	12

COURSES IN MECHANICAL ENGINEERING

Because of existing conditions it may be necessary to cancel certain courses. Students are advised to consult the *Special Announcement* for each term.

1. **Introductory Course in Mechanical Engineering.** Intended to acquaint the student with the field of mechanical engineering. Lectures, bluebooks, and written assignments. Two one-hour periods a week. *Must precede or accompany Mech. Eng. 1a.* One hour credit. Each term.

1a. **Mechanism.** Elementary course covering linkages, cams and followers, gear trains, wrapping connectors, and other mechanisms. Two two-hour periods per week. *Prerequisites: Physics 45 and Drawing 2.* Two hours credit. Each term.

2. **Elements of Machine Design.** The application of the theory of strength and rigidity to machine elements, and a study of the transmission of power by them. Three one-hour recitations per week. *Prerequisites: Drawing 3, Mech. Eng. 1a, and Eng. Mech. 2.* Three hours credit. Each term.

3. **Heat Engines.** Elementary thermodynamics, fuels and combustion, and the principles involved in the application of heat to the various forms of heat engines, including the steam boiler, the steam engine, the steam turbine, the internal-combustion engine, and plant auxiliaries. Lectures, recitations, problems. *Required of all engineering students. Prerequisites: Phys. 45 and 46, and Math. 53.* Four hours credit. Each term.

3a. **Mechanical Engineering Laboratory.** An elective course for students who are not required to take Mech. Eng. 7, intended to give an insight into methods of testing and to exemplify some of the principles of power engineering. *Prerequisite: preceded or accompanied by Mech. Eng. 3.* One hour credit. Each term.

4. **Hydraulic Machinery.** General consideration of the theory, construction, and operation of the principal types of hydraulic machinery. Lectures, problems, and written recitations. *Prerequisite: preceded or accompanied by Eng. Mech. 4.* Three hours credit. Each term.

5. **Thermodynamics.** Principles of energy transformation in steam and internal-combustion engines, air compressors, and refrigerating apparatus. Lectures, recitations. *Prerequisite: Mech. Eng. 3.* Three hours credit. Each term.

6. **Advanced Machine Design.** Analysis, layout, and design of machines and machine parts. Two four-hour periods per week. *Prerequisite: Mech. Eng. 2* Three hours credit. Each term.

7. **Mechanical Engineering Laboratory.** First Course. Elementary testing of a steam engine, steam turbine, oil engine, power pump, and steam boiler; the use and calibration of instruments, and the calculation and interpretation of results. Laboratory, computation, and a few reports; two periods of four and one-half hours each a week. *Prerequisites: Eng. Mech. 1, preceded or accompanied by Mech. Eng. 3, and accompanied by Ch.-Met. Eng. 10.* Two hours credit. Each term.

8. **Mechanical Engineering Laboratory.** Second Course. Experimental study of a steam turbine, Diesel engine, fan, steam injector, air compressor, refrigerating plant, Unaflow steam engine, centrifugal pump, and impulse water turbine. Laboratory, computations, and a few reports; two periods of four and one-half hours each a week. *Prerequisites: Mech. Eng. 7, and preceded or accompanied by Mech. Eng. 5.* Three hours credit. Each term.

9. Power Plants. A study of the engineering, operation, and economics of power plants. Lectures, recitations, and problems. *Prerequisite: Mech. Eng. 3. Open to senior and graduate students.* Three hours credit. Each term.

9a. Design of Power Plants. A study of the type, capacity, and arrangement of equipment to meet the requirements of a modern steam-power plant. The drafting-room work consists of a layout of a plant showing arrangement of principal equipment. Computations and drawing; two four-hour periods a week. *Prerequisites: Mech. Eng. 9 and Eng. Mech. 4.* Three hours credit.

11. Steam-Generating Equipment. A study of commercial types of boilers, stokers, and superheaters; principles of boiler economy and operation; combustion of fuels; theory of heat transference; purchase of coal by specifications; storage of coal; feed-water treatment; problems of design. Lectures, recitations, problems. *Prerequisite: Mech. Eng. 3.* Three hours credit.

11a. Design of Steam-Generating Equipment. This course covers the design of boilers of different types, including calculations and drawing of important details. Drawing problems; two four-hour periods a week. *Prerequisite: Mech. Eng. 2. Not open to students below the senior year.* Three hours credit.

13. Steam Turbines. A study in the application of the laws of thermodynamics, fluid flow, and kinetic effects to the steam turbine. Various types and forms of turbines, and different applications, including electric generation and marine propulsion, are considered together with the general principles of governing. Lectures, recitations, problems. *Prerequisite: Mech. Eng. 5.* Three hours credit.

14. Advanced Thermodynamics. A continuation of Mech. Eng. 5 consisting of the application of principles to advanced problems in heat engines, air compressors, and refrigerating machines, together with lectures dealing with both engineering phases and the relation of the laws of thermodynamics to modern physical concepts of matter and energy. *Prerequisites: Mech. Eng. 5 and 8.* Three hours credit.

15. Internal-Combustion Engines. Theory of Otto and Diesel engines; thermodynamics; fuel; combustion; carburetion; ignition; injection; cooling; lubrication; starting; performance; engine mechanics; balancing and vibration. Discussions, problems. *Must be preceded by Eng. Mech. 3, and preceded or accompanied by Mech. Eng. 5.* Three hours credit. Each term.

15a. Design of Internal Combustion Engines. Calculations, design of important details, and layout drawings of a standard Diesel or Otto type internal-combustion engine. Drawing, problems; two four-hour periods a week. *Prerequisites: Mech. Eng. 2, and preceded or accompanied by Mech. Eng. 15.* Three hours credit. Each term.

16. **Water Turbines.** Covers the hydrodynamic theory of the operation of the various types of water turbines. Considerable attention is given to the analysis of test data and the selection of turbines for various operating conditions. Lectures, recitations, problems. *Must be preceded or accompanied by Mech. Eng. 4* Three hours credit.

16a. **Design of Water Turbines.** Includes calculations and drawings for runners, guide vanes, draft tubes, etc., with special attention given to the layout of runners. Two four-hour periods a week. *Prerequisite: Mech. Eng. 2.* Three hours credit.

17. **Pumping Machinery.** An advanced course covering the theory and operation of reciprocating and centrifugal pumps, the application of pumps to definite pumping problems, economic considerations, and graphical methods. Lectures, recitations, problems. *Prerequisite: Mech. Eng. 4.* Three hours credit.

17a. **Design of Pumping Machinery.** Includes calculations and drawings for a centrifugal or reciprocating pump. Special attention is given to the design of runners, casings, and valves. Two four-hour periods a week. *Prerequisites: Mech. Eng. 2 and 4, and preferably accompanied by Mech. Eng. 17.* Three hours credit.

18. **Heating and Ventilation.** A study of the theory, design, and construction of hot-air, direct- and indirect-steam, hot-water, and fan heating systems, air conditioning, and temperature control. Lectures, recitations. *For architects only.* Two hours credit. Spring term.

19. **Refrigeration and Air Conditioning.** Theory, design, and construction of refrigerating and air-conditioning equipment; characteristics of various refrigerants; the application of refrigeration to cold storage, ice making, and air conditioning. Lectures, recitations, problems. *Prerequisite: Mech. Eng. 5.* Three hours credit.

20. **Materials Handling and Factory Transportation.** A study of materials-handling equipment and its application in modern industrial plants. Considerable time is devoted to the eonomics involved in the use of mechanical-handling equipment and also to the effect on labor. Lectures, recitations, problems, reports, and plant inspection. *Prerequisite: Mech. Eng. 2.* Two hours credit.

20a. **Design of Hoisting and Conveying Machinery.** Calculations and layout work on hoists, cranes, and conveyors. Two four-hour periods a week. *Prerequisite: Mech. Eng. 2. Not open to students below senior year.* Three hours credit. Each term.

21a. **Design of Machine Tools.** Layout and manufacturing drawings of a modern machine tool including a study of bearings, clutches, controls, etc.; computations for strength and rigidity of parts; and the design of power transmission for speeds and feeds. Two four-hour periods a week. *Prerequisite: Mech. Eng. 6.* Three hours credit.

22. **Research in the Mechanical Laboratory.** Opportunity for advanced experimental study along any line of work in which student may be specializing. Laboratory. *Prerequisite: Mech. Eng. 8.* May be elected for two or three hours credit and continued a second term.

23. **Research in the Hydromechanical Laboratory.** Opportunity for advanced experimental study along any line of work in which student may be specializing. Laboratory. *Prerequisite: Mech. Eng. 4.* May be elected for two or three hours credit and continued a second term.

25. **Heating and Ventilation.** Theory, design, and installation of hot-air, direct- and indirect-steam, hot-water, and fan heating systems; central heating; air conditioning; and temperature control. Lectures, recitations. *Prerequisite: Mech. Eng. 3.* Two hours credit. Fall term.

25a. **Design of Heating and Ventilating Systems.** The student is given the usual data furnished the heating and ventilating engineer. He then makes a layout of piping, ducts, and auxiliary apparatus, with computations for the size of principal equipment. Two four-hour periods a week. *Prerequisite: Mech. Eng. 3.* Three hours credit.

26. **Air-Conditioning Laboratory.** Opportunity for advanced experimental study in the field of air conditioning. *Prerequisites: Mech. Eng. 8 and 25.* Two or three hours credit.

27. **Studies in Natural Ventilation.** Theory of air movement through buildings by wind and temperature difference. Deductions from test data at hand. Some experimental work of an illustrative nature, and possibly something of a research nature. *Prerequisite: Mech. Eng. 8.* Two hours credit.

29. **Automobile and Motor Trucks.** Fundamental principles of construction, operation; application in current practice; engine cycle, details of construction, cooling, lubrication, carburetion, electrical systems, clutch, transmission, axle, differential, steering, springs, brakes; engine and car testing, performance curves, operations and control. Lectures, recitations, laboratory demonstrations. *Not open to students below junior year.* Three hours credit. Each term.

30. **Automobile and Truck Engines.** The student selects the type of car or truck; makes expectancy curves for engine performance; and computes the dimensions and sketches principal parts. Lectures, problems, drawing. Two four-hour periods a week. *Prerequisites: Mech. Eng. 6 and 29.* Three hours credit.

30a. Design of Automobile and Motor-Truck Engines. Continuation of Mech. Eng. 30. Lectures, assembly drawing, and details. Two four-hour periods a week. *Prerequisite: Mech. Eng. 30.* Three hours credit.

31. Design of Automobile and Motor-Truck Chassis. The student selects the type of engine for assumed conditions, then computes the dimensions and sketches the principal parts of the chassis. Lectures, problems, drawing. *Prerequisites: Mech. Eng. 6 and 29.* Three hours credit.

31a. Design of Automobile and Motor-Truck Chassis. Continuation of Mech. Eng. 31. Lectures, assembly drawings, and details. *Prerequisite: Mech. Eng. 31.* Three hours credit.

32. Automotive Laboratory. An experimental study of automobile and aircraft engines, including horsepower, fuel economy, thermal efficiency, mechanical efficiency, heat balance, indicator cards, carburetion, compression ratio, electrical systems, and road tests for car performance. Laboratory and reports. Four or five hours each week. *Prerequisites: Mech. Eng. 7 and 29 or 15.* May be elected for three hours credit and continued a second term. Each term.

33. Advanced Automobile Testing and Research. An opportunity for advanced experimental and research work. Laboratory, reports. *Prerequisite: Mech. Eng. 32.* May be elected for three hours credit and continued a second term.

34. Advanced Automobile Design and Research. Special problems in the design of some automobile or truck unit. Drawing. *Prerequisites: Mech. Eng. 30 and 31.* Credit and hours to be arranged.

35. Factory Management. Management problems and methods involved in the operation of manufacturing institutions including location, layout, equipment investment, motion study, time study, methods of wage payment, inspection, organization procedures, production control, material control, and budgets. Lectures, recitations, and problems. *Not open to freshmen and sophomores.* Three hours credit. Each term.

36. Factory Management—Motion and Time Study. Attention is devoted to operating methods, to work-center layout according to the laws of motion economy, and to time-study technique. Exercises in the laboratory and in a co-operating manufacturing plant constitute the work of the course. *Prerequisite: Mech. Eng. 35.* Three hours credit. Each term.

37. Research in Internal-Combustion Engineering. Opportunity for investigation of the theory, design, and construction of internal-combustion engines, and for laboratory research. Credit and hours to be arranged.

40. **Factory Management—Field Work.** The principles of production developed in Mech. Eng. 35 and 36 are in this course applied to specific problems in factory management. The course will consist of inspection trips to manufacturing plants, with problems and discussions based on these trips. Three hours credit.

41. **Automobile-Engineering Seminar.** The student prepares one paper on current topics of the automobile industry and one covering an investigation of some special subject. Reading, preparation of papers, and class discussions. One hour credit. Each term.

42. **Factory Management—Purchasing.** The following topics are considered: inventory management, selection of sources, price analysis, standards and specifications, organization of a purchasing department, government regulations, buying policies, and economics of freight transportation. Lectures, recitations, and term report. *Prerequisite: Mech. Eng. 35.* Three hours credit. Fall term.

60. **Aircraft Power Plants.** A study of the construction and operation of aircraft engines and their auxiliaries. A descriptive course including critical discussion of the reasons for the various types of construction now in service. *Must be preceded or accompanied by Mech. Eng. 3.* Three hours credit. Each term.

61. **Aircraft Power Plants—Experimental Tests.** Experimental study of aircraft engines, test apparatus, and methods, and the determination of their characteristic performance, including speed, timing, mixture ratios, compression ratio, and fuels. *Prerequisites: Mech. Eng. 7 and 60.* Three hours credit. Each term.

62. **Design of Aircraft Engines.** A study of current practice; preliminary calculations for principal dimensions of an aircraft engine, determination of gas pressure and inertia forces and resultant bearing loads; sketches of principal parts. Lectures, drawing. Two three-hour periods a week. *Must be preceded or accompanied by Mech. Eng. 15.* Two hours credit.

63. **Design of Aircraft Engines.** Continuation of Mech. Eng. 62. Further design and sketching of parts, including proposed layout of accessories, followed by the complete layout of final design. Lectures, drawing. Two three-hour periods a week. *Prerequisites: Mech. Eng. 2 and 62.* Two hours credit.

70. **Diesel Power Plants.** A descriptive course covering the construction and operation of Diesel engines for marine, stationary, and automotive purposes, together with their auxiliaries. *Prerequisite: Mech. Eng. 3.* Two hours credit.

72. **Design of Diesel Engines.** A study of current practice; preliminary calculations for principal dimensions of a Diesel engine, determination of gas pressure and inertia forces and resultant bearing

loads; sketches of principal parts. Lectures, drawing. Two three-hour periods a week. *Must be preceded or accompanied by Mech. Eng. 15.* Two hours credit.

73. **Design of Diesel Engines.** Continuation of Mech. Eng. 24. Further design and sketching of parts, including proposed layout of accessories, followed by the complete layout of final design. Lectures, drawing. Two three-hour periods a week. *Prerequisites: Mech. Eng. 2 and 72.* Two hours credit.

80. **Balancing, Critical Speeds, and Gyroscopic Action.** Fundamental equations of dynamics. Static and dynamic balance. Balancing of rotating and reciprocating masses. Balancing machines. Vibrations and damping. Critical speeds. Gyroscopic torque and application of gyroscopic action. Lectures, recitations, and laboratory demonstrations. *Prerequisite: Eng. Mech. 3.* Two hours credit.

60. NAVAL ARCHITECTURE AND MARINE ENGINEERING

Professor BRAGG; Associate Professor BAIER; Assistant Professor ADAMS.

The work in this department has for its object the training of men in connection with the design and construction of ships, their propelling machinery, and auxiliaries. The curriculum is ultimately directed to the following two divisions:

Naval Architecture, which embraces all questions relating to the design and construction of ship hulls, and includes such topics as form, strength, structural details, resistance, powering, stability, estimating, and the methods available for solving the general problem of preliminary and final ship design.

Marine Engineering, which includes those subjects dealing more particularly with the design and construction of the various types of propelling machinery, such as steam-reciprocating, turbine, and oil engines; with boilers of different types; auxiliaries; propellers; and the general problem of heat transference.

In addition to the above two fields of employment in the shipbuilding industry, graduates of this Department frequently become connected wth transportation companies in the operating division. Others have entered the Coast Guard Service or other governmental maritime agencies. Some prefer the small boat field, and specialize in the design, construction, and brokerage of both power and sail yachts. The courses offered in the Department are therefore designed to give a student a thorough training in the fundamental problems relating to the marine field, with certain of them open to elective work in any group which may give him a more specific training in the particular line of work he may wish to follow.

The Department of Naval Architecture and Marine Engineering in planning its course of study has had in mind the fact that the basic work is similar to that in mechanical engineering, with the slight differentiation largely in the fourth year. As a ship represents a floating power plant, fundamental courses in civil, electrical, and chemical engineering are also included. While recognizing the fact that, in the shipbuilding and shipping industry, men are eventually segregated into the above groups, it has been thought advisable to devote more time to the essentials of the subject, rather than to undue specialization in any one, and to give the student as broad a background as possible. If, however, further specialization is desired, it is recommended that the student return for a fifth year and enter the Graduate School. Facilities for research work are provided in the Naval Tank, or Experimental Model Basin, which is unique in this institution.

The Department is in constant touch with all the shipbuilding and shipping establishments, not only in this district, but throughout the country, so as to aid its graduates in obtaining positions in the various lines mentioned above.

Naval Tank. On the first floor of the West Engineering Building the east wing contains the Experimental Model Basin. This tank is 300 feet long and 22 feet wide, with a depth of water of 10 feet. At the south end is a model room and workshop for the purpose of making models of vessels.

The models used in the tank for testing purposes are from 8 to 12 feet, and are made of wood. The tank is spanned by a traveling tow car which is driven by an electric motor and can be run at any required speed. Upon this truck are mounted the dynamometers for measuring the resistance of the models of various forms over a range of speeds. A false steel bottom, 140 feet in length, is hung on threaded bronze rods, allowing adjustment at any desired depth below the water surface, in order to simulate shallow water conditions for testing purposes.

Equipment is available for studies relating to ship resistance, shallow-water effects, streamline flow, wave profiles, wake, and rolling.

Advice to Students of other colleges and universities, with regard to planning their courses before coming to the University, is to be found in section 7.

Military and Naval Science.— The attention of prospective students in naval architecture and marine engineering is called to the Reserve Officers' Training Corps. Those who consider taking military science or naval science are urged to enroll at the beginning of their course. For further details see sections 46 and 49.

CURRICULUM IN NAVAL ARCHITECTURE AND MARINE ENGINEERING AND REQUIREMENTS FOR GRADUATION

Candidates for the degree of Bachelor of Science in Engineering (Naval Architecture and Marine Engineering) are required to complete the curriculum detailed below. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Nontechnical Electives	6
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chem. 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2 and Chem. Eng. 1	5
Economics 53, 54	6
Total	66

b) *Secondary and Technical Courses*	
Surveying 4, Use of Instruments	2
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity of Materials	4
Eng. Mech. 2*a*, Laboratory—Strength of Materials	1
Eng. Mech. 3, Dynamics	3
Eng. Mech. 15, Theory of Structures in Ship Design	3
Mech. Eng. 1*a*, Mechanism	2
Mech. Eng. 2, Elements of Machine Design	3
Mech. Eng. 3, Heat Engines	4
Mech. Eng. 7, Mechanical Laboratory	2
Elec. Eng. 2*a*, Electric Apparatus and Circuits	4
Civil Eng. 2, Theory of Structures	3
Nav. Arch. 11, Introduction to Practice	2
Nav. Arch. 12, Form Calculations—I	3
Nav. Arch. 41, Marine Machinery	3
Nav. Arch. 51, Resistance; Power; Propellers	3
Total	45

c) *Group Options*

Group A—Naval Architecture
(For those principally interested in ship design and hull construction)

Eng. Mech. 4, Fluid Mechanics	3
Nav. Arch. 13, Form Calculations—II	3
Nav. Arch. 21, Structural Design	3
Nav. Arch. 31, Ship Design I	3
Nav. Arch. 32, Ship Design II	3
Nav. Arch. 33, Contracts and Specifications	1
Nav. Arch. 34, Cost Estimating	1
Nav. Arch. 52, Naval Tank	2
Free Electives	10
Total	29

Group B—Marine Engineering

(For those who wish to specialize in the design of propelling and other ship machinery)

	Hours
Mech. Eng. 4, Hydraulic Machinery	3
Mech. Eng. 5, Thermodynamics	3
Mech. Eng. 8, Mechanical Laboratory	3
Mech. Eng. 13, Steam Turbines	3
Mech. Eng. 15, Gas Engines	3
Mech. Eng. 9*a*, Design of Power Plants or Nav. Arch. 42, Marine Boiler Drawing and Design or Nav. Arch. 43, Marine Engine Drawing and Design	3
Free Electives	11
Total	29

Summary:

Preparatory Courses	66
Secondary and Technical Courses	45
Group Options	29
Total	140

PROGRAM

FIRST TERM		SECOND TERM	
COURSES	HOURS	COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4	Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 1	3	*English 2	1
Drawing 1	3	*English 3	2
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5	Drawing 2	3
Assembly	0	†Ch.-Met. Eng. 1 and Metal Proc. 2 or Chem. 5E	5
‡Physical Ed.	0	Assembly	0
or (Mil. Science)	(1)	‡Physical Ed.	0
	15 or (16)	or (Mil. Science)	(1)
			15 or (16)

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

‡ Physical education two or three times a week throughout the year (without credit in hours) is required of all first-year students, unless military or naval science (one hour's credit each term) is elected as a substitute. Enrollment in military or naval science is for a period of four terms.

THIRD TERM

COURSES	HOURS
Math. 53 (Calculus I)	4
Physics 45	5
Drawing 3	2
English (Group II)	2
Eng. Mech. 1	3
(Mil. Science)	(1)
	16 or (17)

FOURTH TERM

COURSES	HOURS
Math. 54 (Calculus II)	4
Physics 46	5
Eng. Mech. 2	4
Eng. Mech. 2*a*	1
Mech. Eng. 1*a*	2
(Mil. Science)	(1)
	16 or (17)

FIFTH TERM

Nav. Arch. 11	2
Mech. Eng. 3	4
Eng. Mech. 15	3
Elec. Eng. 2*a*	4
*Elective	3
	16

SIXTH TERM

	Group A	*Group B*
Nav. Arch. 12	3	3
Nav. Arch. 13	3	
Mech. Eng. 7	2	2
Civil Eng. 2	3	3
Mech. Eng. 2	3	3
Mech. Eng. 5		3
*Elective	2	2
	16	16

SEVENTH TERM

	Group A	*Group B*
Nav. Arch. 21	3	
Surveying 4	2	2
Eng. Mech. 4	3	
Mech. Eng. 4		3
Eng. Mech. 3	3	3
Economics 53	3	3
Mech. Eng. 8		3
*Elective	2	2
	16	16

EIGHTH TERM

	Group A	*Group B*
Nav. Arch. 41	3	3
Nav. Arch. 31	3	
Mech. Eng. 15 or 13		3
Economics 54	3	3
English (Group III)	2	2
Nav. Arch. 52	2	
*Elective	3	5
	16	16

NINTH TERM

	Group A	*Group B*
Nav. Arch. 51	3	3
Nav. Arch. 32	3	
†Design Course		3
Mech. Eng. 13 or 15		3
Nav. Arch. 33	1	
Nav. Arch. 34	1	
*Elective	6	5
	14	14

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* Total electives are to be made up of 6 hours' nontechnical and the balance free electives, except for those taking military science, where the 4 hours in this department are deducted from the required nontechnical electives.

† Design course for Group B. May take Mech. Eng. 9*a* or Nav. Arch. 42 or Nav. Arch. 43, for 3 hours.

PROGRAM FOR NAVAL R.O.T.C. STUDENTS

FIRST TERM

COURSES	HOURS
Math. 13 (Alg. and Anal. Geom.)	4
*English 1	3
Drawing 1	3
†Chem. 5E or Ch.-Met. Eng. 1 and Metal Proc. 2	5
Assembly	0
Nav. Science 21	1
	16

SECOND TERM

COURSES	HOURS
Math. 14 (Pl. and Sol. Anal. Geom.)	4
*English 2	1
*English 3	2
Drawing 2	3
†Ch.-Met. Eng. 1 and Metal Proc. 2 or Chem. 5E	5
Assembly	0
Nav. Science 22	1
	16

THIRD TERM

Math. 53 (Calculus I)	4
Physics 45	5
Drawing 3	2
English (Group II)	2
Eng. Mech. 1	3
Nav. Science 31	1
	17

FOURTH TERM

Math. 54 (Calculus II)	4
Physics 46	5
Eng. Mech. 2	4
Nav. Science 32	1
Nav. Science 60 (Nav.)	2
	16

FIFTH TERM

Nav. Arch. 11	2
Elec. Eng. 2*a*	4
Mech. Eng. 3	4
Eng. Mech. 15	3
Nav. Science 41*a*	2
Nav. Science 61 (Nav.)	2
	17

SIXTH TERM

	Group A	*Group B*
Nav. Arch. 12	3	3
Nav. Arch. 13	3	
Civil Eng. 2	3	3
Eng. Mech. 2*a*	1	1
Mech. Eng. 5		3
Mech. Eng. 7	2	2
Nav. Science 42*a*	2	2
Nav. Science 62 (Nav.)	2	2
	16	16

SEVENTH TERM

	Group A	*Group B*
Mech. Eng. 1*a*	2	2
Mech. Eng. 2	3	3
Mech. Eng. 4		3
Mech. Eng. 8		3
Eng. Mech. 4	3	
Economics 53	3	3
Nav. Science 51*a*	2	2
Nav. Arch. 21	3	
	16	16

EIGHTH TERM

	Group A	*Group B*
Nav. Arch. 31	3	
Nav. Arch. 41	3	3
Mech. Eng. 13 or Mech. Eng. 15		3
Economics 54	3	3
Eng. Mech. 3	3	3
Nav. Science 52	2	2
Nav. Science 52*a*	2	2
	16	16

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* If modern language is elected, it may be classified here and the English postponed. See section 34.

† See note, section 39.

NINTH TERM

	Hours	
	Group A	*Group B*
Nav. Arch. 32	3	
Nav. Arch. 33	1	
Nav. Arch. 34	1	
Nav. Arch. 51	3	3
Nav. Arch. 52	2	
*Design Course		
Mech. Eng. 15 or Mech. Eng. 13		3
English (Group III)	2	2
Surveying 4	2	2
	14	13

Advanced Course Cruise—No departmental credit.

COURSES IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

Group 10

11. **Introduction to Practice.** An introductory course describing types of ships, nomenclature, methods and materials of construction, shipyard practice, and drawing-room details. The lines of a small vessel are faired, and drawings prepared of simple ship structures. Details of shell expansion and other mold loft work are discussed. Lectures, recitations, and drawing room. *Prerequisites: Draw. 1 and 2.* Two hours credit. Each term.

12. **Form Calculations—I.** This course takes up the study of methods of determining areas, volumes, centers of buoyancy, displacement and wetted surface; the use of hydrostatic curves; trim; initial and statical stability; stability in damaged condition; and watertight subdivision. Lectures and recitations. *Prerequisites: Nav. Arch. 11, Math. 54, and Eng. Mech. 1.* Three hours credit. Each term.

13. **Form Calculations—II.** In this course the student prepares a body plan from given offsets and makes the necessary calculations for the preparation of hydrostatic, launching, and flooding curves. Drawing room. *Preceded or accompanied by Nav. Arch. 12.* Three hours credit. Each term.

Group 20

21. **Structural Design.** Comprises a discussion and practice in the design of the ship's principal structure and fastenings to meet

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* Design course for Group B. May take Mech. Eng. 9*a* or Nav. Arch. 42 or Nav. Arch. 43, for 3 hours.

the general and local strength requirements. A thorough study is made of the application of the Classification Societies' rules to framing, connections, shell, decks, bulkheads, welding, riveting, and testing. Lectures, recitations, and drawing room. *Prerequisites: Eng. Mech. 2 and Nav. Arch. 12. Preceded or accompanied by Nav. Arch. 13, Eng. Mech. 15, and Civ. Eng. 2.* Three hours credit. Each term.

Group 30

31. **Ship Design—I.** Includes a review of statical stability and continues with the dynamical stability of ships. Discussions follow concerning rolling, pitching, and seagoing qualities of ships; rudders, turning and maneuvering; freeboard; tonnage; grounding and deflections. The latter part of the course is devoted to estimates and calculations involved in the preliminary design of ships. Lectures and recitations. *Prerequisites: Nav. Arch. 13 and 21.* Three hours credit. Spring term 1943 and alternate terms thereafter.

32. **Ship Design—II.** In this course the student is given the owner's general requirements and prepares a complete design of a suitable ship, including form, power, and strength calculations; midship section, lines, profiles, and arrangement plans. Drawing room. *Prerequisites: Nav. Arch. 21 and 31.* Three hours credit. Each term.

33. **Contracts and Specifications.** Covers a discussion of the principal features of ship specifications and contracts. Lectures and recitations. One hour credit. First half of the fall term 1942 and alternate terms thereafter.

34. **Cost Estimating.** Includes methods and practice of estimating costs of repair work and new construction. Lectures and recitations. One hour credit. Second half of the fall term 1942 and alternate terms thereafter.

35. **Advanced Ship Drawing and Design.** Credit to be arranged.

Group 40

41. **Marine Machinery.** Familiarizes the student with the different types of machinery used for propelling vessels. A complete study is made of the principles of heat transference with attention to the steam consumption of reciprocating engines and turbines, and of the capacity of different types of boilers to supply steam for their needs. The use of coal, pulverized coal, and fuel oil in connection with boilers is studied, and also the use of oil in internal-combustion engines. A brief study is made also of condensers and air pumps. Lectures, recitations. *Prerequisites: Mech. Eng. 3 and Eng. Mech. 1.* Three hours credit. Spring term 1943 and alternate terms thereafter.

42. **Marine Boiler Drawing and Design.** In this course a Scotch marine boiler of general type is designed. Drawing room. Three hours credit. Each term.

43. Marine Engine Drawing and Design. The complete general plans of a triple- or quadruple-expansion engine are prepared, together with all calculations for the same. Drawing room. Three hours credit. Each term.

44. Advanced Machinery Drawing and Design. Credit to be arranged.

45. Advanced Reading and Seminar in Marine Engineering. Credit to be arranged.

Group 50

51. Resistance; Power; Propellers. In this course all items affecting the resistance and propulsion of various ships' forms, investigation of the theory and practice involved in the design of propellers, and methods of conducting trial trips, etc., are discussed. Lectures and recitations. *Prerequisite: Nav. Arch. 12.* Three hours credit. Fall term 1942 and alternate terms thereafter.

52. Naval Tank. The theory of model testing, with particular attention to surface vessels is discussed, and the student familiarized with the methods of estimating speed, power, and revolutions. A model is towed in the tank, and resistance, trim, wake, and other data worked up. Lectures, drawing room, and laboratory. *Prerequisites: Eng. Mech. 4. Preceded or accompanied by Nav. Arch. 31.* Two hours credit. Each term.

53. Research in Naval Tank. Credit to be arranged.

54. Advanced Reading and Seminar in Naval Architecture. Credit to be arranged.

55. Piloting and Celonavigation. Given in Detroit one evening per week as part of the Extension Service. Two hours credit. (Nontechnical elective.)

61. PHYSICS

Professors Barker, Colby, Smith, Sawyer, Goudsmit, Dennison, Lindsay, Duffendack, Cork, and Uhlenbeck; Associate Professors Meyer, Rich, Sleator, Laporte, Firestone, and Crane.

The Department of Physics offers instruction in general physics and also in a number of special fields. It is well equipped with apparatus for lecture demonstrations, for laboratory experiments, and for a great variety of research investigations. The classes in general physics are held in the West Physics Building, which contains classrooms, laboratories, two lecture rooms, and the instrument shop. Advanced work and research are carried on in the Harrison M. Randall Laboratory of Physics, which also houses the departmental library and offices. Several research laboratories in this building are devoted to investigations of industrial problems directed by members of the staff in collaboration with the Department of Engineering Research.

The introductory courses (45 and 46) consisting of three recitations, two demonstration lectures, and a two-hour laboratory period each week for two terms, provide a thorough training in the fundamental principles of mechanics, heat, sound, light, and electricity. They are required of all engineering students. Physics 45 is a prerequisite for all other courses in the Department, and Physics 46 for all subsequent courses except Physics 130.

CURRICULUM IN PHYSICS

The inclusion of a degree in physics, among other degrees offered by this college, has its justification in the rapid introduction of the findings of physics and the methods of physical research into industry. The demand for physicists far exceeds the supply, and is continually increasing. Any one finding the subject attractive may become an industrial physicist, confident that his profession is one of great usefulness and ever-expanding possibilities.

The schedule of courses leading to the degree of Bachelor of Science in Engineering (Physics) is given below. The Department will be glad to consult with any interested student, both as to the possibilities of this profession and the particular work best suited to the individual.

Since this curriculum leads to fields other than engineering it is not listed for accrediting with the Engineers' Council for Professional Development.

Candidates for the degree of Bachelor of Science in Engineering (Physics) are required to complete the following curriculum. For the definition of an hour of credit see section 33.

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, Group II, Group III	10
Modern Language (preferably German or French)	8
Mathematics 13, 14, 53, 54, 57	18
Physics 45, 46, 147, 165, 196	20
Chemistry 5E, 21E, 188*	13
Drawing 1	3
Ch.-Met. Eng. 1 and Metal Proc. 2	5
Total	77

b) *Secondary and Technical Courses*	
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Elec. Eng. 2, Direct Current Apparatus and Circuits	4
Elec. Eng. 3, Alternating Current Circuits	4
Total	15

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* Students in this curriculum may elect Chem. 188 without having had Chem. 21E.

c) Options and Electives	*Hours*
Options in Physics	13
Options in Chemistry	3
Options in Mathematics	3
Options in Engineering	10
Electives from Economics, Geography, History, Philosophy, Political Science, Sociology	6
Free Electives	13
Total	48

Summary:

Preparatory Courses	77
Secondary and Technical Courses	15
Options and Electives	48
Total	140

COURSES IN PHYSICS

45. Mechanics, Sound, and Heat. Two lectures, three recitations, and one two-hour laboratory period each week. *Prerequisites: one year of high-school physics or college chemistry; trigonometry is essential, and calculus should be elected simultaneously with physics.* Five hours credit. Each term.

46. Electricity and Light. A continuation of Phys. 45 *which must precede it.* Two lectures, three recitations, and one two-hour laboratory period a week. Five hours credit. Each term.

105. Modern Physics. A discussion of fundamental experiments on the nature of light, electricity, and matter. *Prerequisite: Phys. 46.* Two hours credit. Fall term.

130. Architectural Acoustics. Practical control of reverberation, sound transmission through walls, and vibration insulation, as applied to the acoustics of buildings. *Primarily for architects. Prerequisite: Phys. 45.* One hour credit. Spring term.

147. Electrical Measurements. Methods of measuring current, resistance, electromotive force, capacitance, inductance, and hysteresis of iron, and the calibration of the instruments employed. This course is in the curriculum in electrical engineering. *Must be preceded or accompanied by Elec. Eng. 3.* Two lectures and one four-hour laboratory period a week. Four hours credit. Spring term.

154. Electrical Measurements. Alternating and transient currents. Measurement of inductance and capacitance by audio-frequency currents and vacuum-tube amplifiers. Alternating-current bridge circuits. Hysteresis curves. *Prerequisite: Phys. 145 or 147.* Four hours credit. Fall term.

165. **Electron Tubes.** The characteristics of electron tubes and their functions as detectors, amplifiers, and generators. Three hours credit. Fall term.

166. **High-Frequency Electrical Measurements.** A laboratory course dealing with radio-frequency problems. *Prerequisite: Phys. 165.* Two hours credit. Spring term.

171. **Mechanics of Solids.** Statics and dynamics; the equations of d'Alembert, Poisson, Laplace, and Lagrange. Three hours credit. Fall term.

172. **Mechanics of Fluids.** Statics and elementary dynamics. Center of pressure, stability, viscosity, capillarity, and the equations of motion of a fluid. *Prerequisite: Phys. 171 or equivalent.* Two hours credit. Spring term.

175. **Sound.** Mathematical study of waves and of vibrating mechanical systems using complex numbers. Two hours credit. Fall term.

176. **Laboratory Work in Sound.** Use of vacuum-tube oscillators and amplifiers in the measurement of sound intensity and the calibration of acoustical instruments. *Must be preceded by Phys. 175, and it is recommended that Phys. 165 (electron tubes) be taken before Phys. 176.* Two hours credit. Spring term.

181. **Heat.** Thermal expansion, specific heats, change of state and van der Waals' equation; elementary kinetic theory, and the absolute scale of temperature. Two hours credit. Spring term.

183. **Laboratory Work in Heat.** To follow or accompany Phys. 181. Use of modern methods and instruments for the measurement of thermal quantities. Two hours credit. Spring term.

186. **Light.** Theory of interference, diffraction, polarization, double refraction, etc. Two hours credit. Fall term.

188. **Laboratory Work in Light.** To accompany or follow Phys. 186. Experiments on interference, diffraction, polarization, double refraction, and the fundamental properties in light. Two hours credit. Fall term.

190. **X-Rays.** The emission, absorption, refraction, and diffraction of x-rays, with special emphasis on the interpretation of spectroscopic results. Three hours credit. Spring term.

191. **Introduction to Theoretical Physics.** A survey of the procedures employed in the mathematical formulation and solution of problems in theoretical physics. Recommended as a preparation for the courses numbered 205 and above. Two hours credit. Spring term.

196. Atomic and Molecular Structure. A review of recent developments, based on fundamental experiments. This includes the determination and description of characteristic energy levels, and the classification of electrons. Three hours credit. Spring term.

197. Nuclear Physics. Natural radioactivity; nuclear physics apparatus and methods of nuclear physics. Artificial transmutations and cosmic rays. *Prerequisite: Phys. 105 or 196.* Two hours credit. Spring term.

199. Nuclear Physics Laboratory. The properties of alpha, beta, and gamma rays; the half-life periods and chemical properties of radio-active materials. *To be preceded or accompanied by Phys. 197.* One hour credit. Spring term.

203, 204. Molecular Physics. Introduction to the theories of matter and radiation. Intended primarily for students in chemical engineering. *Phys. 203 is a prerequisite for 204.* Three hours credit each. Fall term, Phys. 203; spring term, Phys. 204.

205, 206. Electricity and Magnetism. A fundamental treatment of electromagnetic theory. Maxwell's equations and the radiation from a Hertzian oscillator. The connection with the special relativity theory. *Prerequisite: Phys..154 or 147.* Three hours credit each. Summer term, Phys. 205; fall term, Phys. 206.

207, 208. Theoretical Mechanics. The Lagrange equations of motion, the principle of least action, Hamilton's principle, the Hamilton-Jacobi equation, Poisson brackets. *Prerequisite: an adequate knowledge of differential equations. Phys. 207 is a prerequisite for Phys. 208. An introductory course in mechanics is desirable.* Three hours credit each. Fall term, Phys. 207; spring term, Phys. 208.

209. Thermodynamics. The two laws and their foundation. Gas equilibria and dilute solutions. The phase rule of Gibbs. Theory of binary mixtures. *Prerequisite: Phys. 181.* Three hours credit. To be offered in the summer of 1943.

210. The Kinetic Theory of Matter. The kinetic and statistical methods of Boltzmann, and the explanation of the second law. Extension to the quantum theory. Nonideal gases and the theory of the solid body. The theory of radiation. Fluctuation phenomena. *Prerequisite: Phys. 209.* Three hours credit. Fall term.

211, 212. Quantum Theory and Atomic Structure. The quantization of multiple periodic systems with applications to atomic spectra (optical and x-ray) and molecular spectra. Heisenberg's uncertainty principle, matrix mechanics, de Broglie waves and the Schrödinger wave equation. *Prerequisite: Phys. 196. Phys. 211 is a prerequisite for Phys. 212.* Three hours credit each. Fall term, Phys. 211; spring term, Phys. 212.

[213, 214. **Introduction to Theoretical Physics.** The partial differential equations of mathematical physics. Three hours credit each. Omitted in 1942-43.]

215, 216. **Special Problems.** Qualified graduate students who desire to obtain research experience in work supervised by members of the staff may, upon consultation, elect these courses. Hours and credit to be arranged. Fall term, Phys. 215; spring term, Phys. 216.

[238. **Nuclear Theory.** Forces between elementary particles; nuclear statistics. Scattering and capture problems. Nuclear models. *Prerequisites: Phys. 211, and 197 or its equivalent.* Three hours credit. Omitted in 1942-43.]

265. **Conduction of Electricity Through Gases.** Theory of conduction; the electric spark, glow discharge, and electric arc; origin of spectra; energy levels in line and band spectra. Three hours credit. Fall term.

Part IV

COMBINED CURRICULA

Since these curricula lead to fields other than engineering they are not listed for accrediting with the Engineers' Council for Professional Development.

62. ENGINEERING-BUSINESS ADMINISTRATION COMBINED CURRICULUM

The College of Engineering and the School of Business Administration offer a combined course to meet the needs of those students who desire dual preparation in the fields of engineering and business administration. Such preparation seems appropriate because of the complicated economic organization of today and the close practical relationship between business activities and technology. More specifically, such a combination is desirable for those who look forward to engaging in contracting, factory management, industrial personnel management, the marketing of industrial equipment, the management of public utilities, or other businesses in which the scientific and technical aspects are prominent.

The combined course covers the general training in engineering essential for this purpose, together with a complete and well-rounded training in business administration. The course in business administration comprises four terms, and ordinarily a bachelor's degree is required for admission to it. Under the combined curriculum, however, a student is registered in the School of Business Administration after the completion of the six- or seven-term prescribed curriculum in the Engineering College, with a minimum average grade of 2.5. Upon the satisfactory completion of the second term of the business administration curriculum, the student will be recommended for the degree of Bachelor of Science in Engineering (Business Administration). Upon the satisfactory completion of the fourth term in the business administration program, the degree of Master of Business Administration will be granted.

The following schedule for the work in the College of Engineering has been approved by the two faculties as the general requirement for the Engineering-Business Administration combined course.

Substitutions may be made by students subject to approval by the Committee on Combined Courses. For the definition of an hour of credit see section 33, and for the grading system see section 24.

CURRICULUM IN ENGINEERING-BUSINESS ADMINISTRATION

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Math. 13, 14, 53, 54	16
Physics 45, 46	10

	Hours
Chemistry 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2 and Ch.-Met. Eng. 1	5
Total	54

b) *Secondary Courses*

Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Mech. Eng. 3, Heat Engines	4
Economics 53, 54, General Economics	6
Economics 71, 72, Accounting	6
Total	23

c) *Selected Electives*

The student shall elect one of the following optional groups:

Chemical and Metallurgical Option—Chem. 21E, 53, 170, Ch.-Met. Eng. 2, 11, 17, 25, E.E. 2*a*; (students in metallurgical engineering will substitute Ch.-Met. Eng. 28 for Ch.-Met. Eng. 25.)

Civil Option—C.E. 2*c*, 3, 5*a*, 10, 30, 42*c*, Surv. 1, E.M. 2*a*, E.M. 3, 4, E.E. 2*a*

Electrical Option—E.E. 2, 3, 4, 17, E.M. 2*a*, 3, 4, C.E. 2

Mechanical Option—M.E. 1, 2, 5, 7, C.E. 2, E.M. 2*a*, 3, 4, E.E. 2*a*, M.P. 4

d) The balance of the 34 hours shall be selected from:

Economics, Engineering, English, History, Military and Naval Science up to 4 hours, Modern Language, Philosophy, Political Science, Psychology, and Sociology....34

Summary:

Preparatory courses	54
Secondary and technical courses	23
Selected electives and options	34
Total	111

63. ENGINEERING-FORESTRY (WOOD TECHNOLOGY) COMBINED CURRICULUM

The College of Engineering and the School of Forestry and Conservation offer a combined curriculum to meet the needs of students who plan to enter one of the wood-using industries and who desire a broad engineering foundation for their work in wood technology.

This program recognizes the fact that intelligent utilization of wood requires not only a thorough knowledge of its structure, properties, and uses, but also of the machinery and processes involved in its manufacture and treatment.

The combined curriculum aims to turn out well-rounded professional men with sufficient training in both engineering and wood technology to qualify them for effective service as technicians, executives, or investigators in the lumber or other wood-using industries, or in some specific aspect of wood utilization, such as kiln drying, preservative treatment, or timber testing.

The student in the combined course is registered in the College of Engineering for six or seven terms, on the completion of which, with a minimum average grade of 2.5, he is recommended for transfer to the School of Forestry and Conservation. On the satisfactory completion of the second term in that school the student will be recommended for the degree of Bachelor of Science in Engineering (Forestry-Wood Technology).

On the satisfactory completion of his fourth term in the School of Forestry and Conservation, and the meeting of that school's specific requirements for graduation, he will be recommended for the degree of Master of Forestry (Wood Technology).

The following schedule which is based on the nine-term program in mechanical engineering, has been approved by the two faculties as the general requirement for the first three years of the combined curriculum. Modifications or substitutions may be made subject to the approval of the committee in charge.

Students who follow a program in some other branch of engineering—for example, civil engineering—will be permitted to take advantage of the combined curriculum, provided (*a*) that during their last three terms in the College of Engineering they make such substitutions in the regular program as may be approved by the head of the department concerned and by the committee in charge, and (*b*) that during their first or second term in the School of Forestry and Conservation they take such supplementary courses in engineering as are similarly approved. For the definition of an hour of credit see section 33, and for the grading system see section 24.

CURRICULUM IN ENGINEERING-FORESTRY

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chemistry 5E	5
Drawing 1, 2, 3	8
Metal Proc. 1, 4	6
Metal Proc. 2 and Ch.-Met. Eng. 1	5
Total	60
b) *Secondary and Technical Courses*	
Surveying 4	2
Eng. Mech. 1, Statics	3

	Hours
Eng. Mech. 2, Strength and Elasticity of Materials	4
Eng. Mech. 2*a*, Strength and Elasticity Laboratory	1
Eng. Mech. 3, Dynamics	3
Eng. Mech. 4, Fluid Mechanics	3
Elec. Eng. 2*a*, Electric Apparatus and Circuits	4
Mech. Eng. 1, Introduction to Mech. Eng.	1
Mech. Eng. 2, Elements of Machine Design	3
Mech. Eng. 3, Heat Engines	4
Mech. Eng. 5, Thermodynamics	3
Mech. Eng. 7, Laboratory	2
Ch.-Met. Eng. 10, Utilization of Fuels	1
Chemistry 63, Organic Chemistry	4
Economics 53, 54, General	6
Botany 1, Elements of	4
Total	48

Summary:

Preparatory Courses	60
Secondary and Technical Courses	48
Total in Engineering	108

64. ENGINEERING-LAW COMBINED CURRICULUM

The College of Engineering and the Law School of the University offer a combined course to meet the needs of those members of the bar whose practice is in fields for which an engineering foundation is desirable.

Such fields include patent law, for which a knowledge of mechanical and electrical devices and of processes is important, and law as affecting the operation and the business of public service, manufacturing, and other corporations.

There is, moreover, an increasing tendency for graduates in law to engage in the management of corporations. The combined course should therefore be of value to many also who are not actively engaged in the practice of law.

The student in the combined course is registered in the College of Engineering for six or seven terms and then in the Law School for a like period. On the completion of the curriculum in the College of Engineering with a minimum average grade of 2.5, the student is recommended for transfer to the Law School. On the satisfactory completion of the second term of the law curriculum, the student will be recommended for the degree of Bachelor of Science in Engineering (Law).

The following schedule for the work in the College of Engineering has been approved by the two faculties as the general requirement for the Engineering-Law combined course. Modifications or substitutions in the purely engineering courses may be made, subject to the permission of the committee in charge. For the definition of an hour of credit see section 33, and for the grading system see section 24.

CURRICULUM IN ENGINEERING-LAW

a) *Preparatory Courses*	*Hours*
English 1, 2, 3, and a course from Group II	8
English, junior-senior, a course from Group III	2
Math. 13, 14, 53, 54	16
Physics 45, 46	10
Chemistry 5E	5
Drawing 1, 2, 3	8
Metal Proc. 2 and Ch.-Met. Eng. 1	5
Total	54

b) *Secondary and Technical Courses*	
Surveying 4	2
Eng. Mech. 1, Statics	3
Eng. Mech. 2, Strength and Elasticity	4
Eng. Mech. 2*a*, Strength and Elasticity Laboratory	1
Eng. Mech. 3, Dynamics	3
Eng. Mech. 4, Fluid Mechanics	3
Civil Eng. 2, Theory of Structures	3
Elec. Eng. 2*a*, Electric Apparatus and Circuits	4
Mech. Eng. 2, Elements of Machine Design	3
Mech. Eng. 3, Heat Engines	4
Mech. Eng. 5, Thermodynamics	3
Economics 53, 54, General Economics	6
Political Science 107, 108, American Government	6
Total	45

c) Electives to be selected from the following group:	
Accounting, Astronomy, Chemistry, Economics, Technical Engineering, English, Geology, History, Mathematics, Modern Language, Physics, Political Science, Psychology	12

Summary:	
Preparatory Courses	54
Secondary and Technical Courses	45
Selected Electives	12
Total in Engineering	111

COLLEGE OF ENGINEERING
SUMMARY OF STUDENTS
1941–1942

	1st Year	2d Year	3d Year	4th Year	Special	Total
Civil		34	20	17	3	74
Mechanical		173	103	140		416
Electrical		56	45	41	1	143
Chemical		133	119	90	1	343
Naval Arch. & Marine		39	25	43	2	109
Aeronautical		140	115	101		356
Geodesy & Surveying				2		2
Engineering Mechanics				5	1	6
Mathematics			3	12		15
Physics		8	4	14	1	27
Mechanical & Industrial		7	5	10		22
Engineering-Law		2	8	4		14
Transportation		4	13	4		21
Engr.-Business Admin.		9	8			17
Engineering-Forestry		2	1			3
Metallurgical		17	27	29	1	74
General Special					3	3
Unclassified, 1st year	618					618
Grand Total	618	624	496	512	13	2,263
Counted Twice		15	21	24		60
Net Total in Engineering	618	609	475	488	13	2,203

Undergraduates, College of Engineering	2,203
Students in Engineering enrolled in Summer Session 1941	362
Students in Engineering enrolled in Graduate School	127
Students enrolled in Engineering* Extension Courses	139
Net total number of students in Engineering	2,549

* Extension students have been grouped according to Schools and Colleges from which instructors offering courses have been drawn. This does not indicate enrollment of the Extension Service students in the Schools and Colleges.

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PART V

Medical School

1942–1943

1943–1944

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